Vic-2D

Reference Manual

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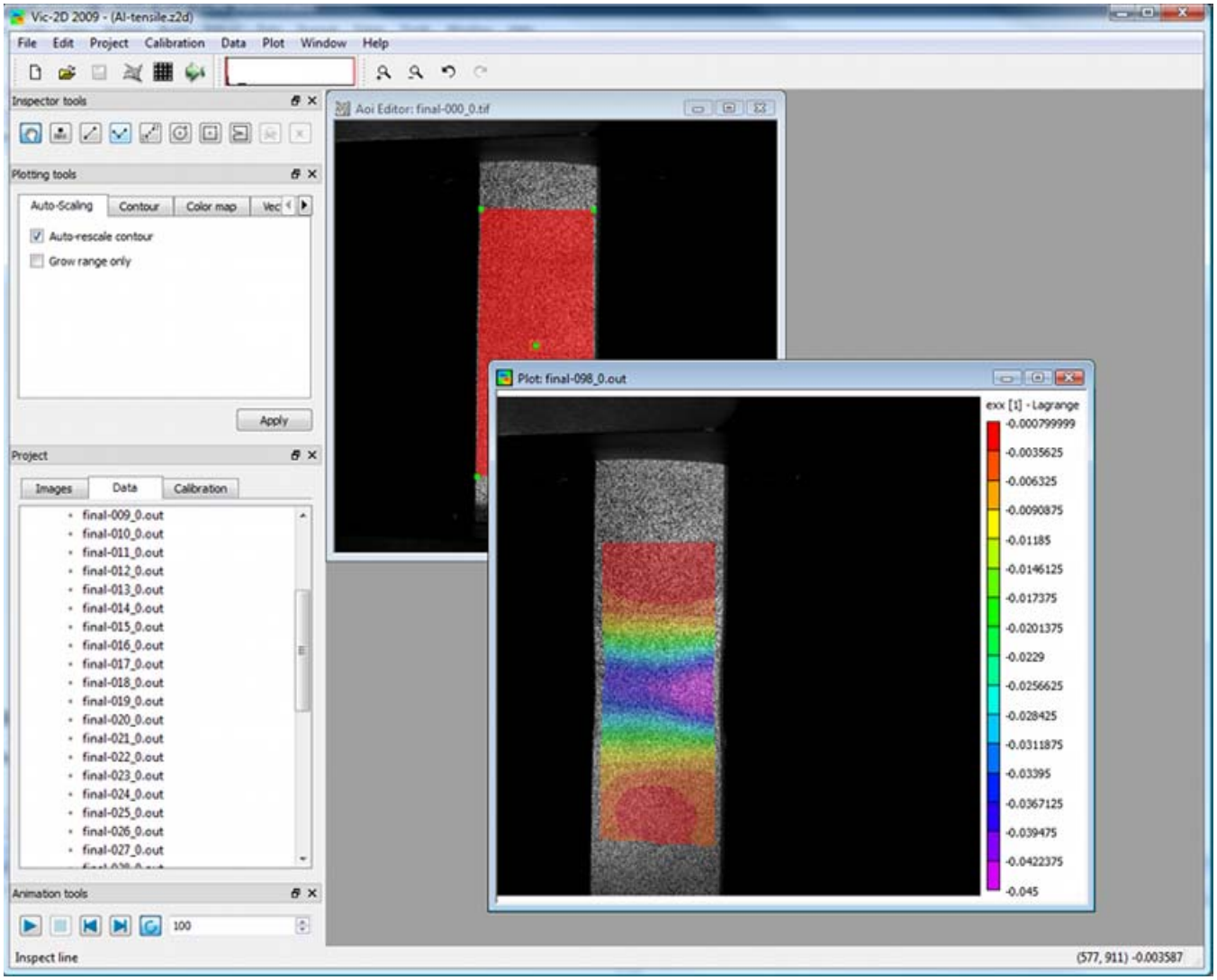
Overview

The user interface of Vic-2D has many of the familiar control elements found in other applications. The image below illustrates the user interface. The most commonly used functions can be accessed by clicking on tool buttons on the **Tool Bar**. The windows, such as the **AOI Editor** and **Plot** windows are grouped inside a **Workspace**. The **List View** on the left of the main window provides a quick overview of image and data files.



File Menu

The *File Menu* provides the following functions:

- **New** - creates a new project
- **Open** - open an existing project
- **Save** - save the current project
- **Save As...** - save the current project under a new file name
- **Mode** - select a Vic-2D project type
- **Install module licenses** - use this menu entry to activate software modules you have purchased
- **Quit** - quit Vic-2D

Edit Menu

The *Edit Menu* provides the following functions:

- **Undo** - undo the last editing operation in the reference image
- **Redo** - redo the last editing operation in the reference image
- **Pan/Select** - pan around in a zoomed-in image, or select an existing AOI
- **Line** - create a Line AOI
- **Rectangle** - create a Rectangle AOI
- **Polygon** - create a Polygon AOI
- **Cut Region** - cut a region from a polygon or rectangle AOI
- **Delete** - removes the selected AOI
- **Initial Guess** - show the Initial Guess Dialog to select an initial guess for the currently active AOI

Project Menu

The *Project Menu* provides the following functions:

- **Speckle images**- adds speckle images to the project for analysis.
- **Speckle image folder**- adds all speckle images from a given folder.
- **Speckle image list** - adds speckle images from a text-based list.
- **Calibration images** - adds calibration images to the project.
- **Data files** - adds pre-existing output data files to the project
- **Analog data** - adds analog data files from Vic-Snap
- **Video clip** - adds generated AVI files

Calibration Menu

The *Calibration Menu* provides the following functions:

- **Calibrate scale** - allows calibration for physical scale.
- **Distortion correction** - allows correction for nonparametric distortions.
- **Clear distortion** - clears calculated distortion map.
- **More** - additional functions including Aspect Ratio selection

Data Menu

The *Data Menu* provides the following functions:

- **Start analysis** - shows the Run dialog to begin analysis
- **Apply math operation** - allows manipulation of output data
- **Export statistics** - exports group statistics for output data
- **Postprocessing options** - shows a submenu to choose from various postprocessing calculations
- **Export data** - exports output data for use with external software
- **Extract grid data** - extracts and outputs data on a regular pixel grid

Plot Menu

The *Plot Menu* provides the following functions:

- **New plot**- adds a new plot window to the work space
- **Inspector**- allows choice of various data inspection tools

Window Menu

The *Window Menu* provides the following functions:

- **Cascade** - organizes all MDI windows in a cascade
- **Tile** - tiles all MDI windows

Help Menu

The *Help Menu* provides the following functions:

- **User manual** - show this manual.
- **About** - show version information.

Main Toolbar

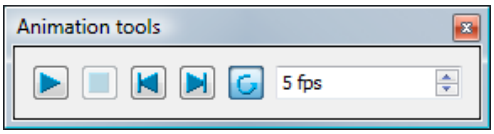
The buttons on the main toolbar control commonly used Vic-2D functions. From left to right:

- New project
- Open project
- Save project
- Add speckle images
- Add calibration images
- Start analysis
- Calculate strain
- Histogram control
- Zoom in/out
- Undo/redo

The histogram control displays the gray level distribution for the currently displayed image. The red bars on the histogram may be used to adjust the image display. Double-click on the histogram to automatically adjust the balance, or drag the red bars to set the black and white levels manually. Double click again to remove the balance adjustment.

The balance control is for display only and does not affect image analysis or stored images.

Animation Toolbar



The buttons on the animation toolbar allow stepping through and animating image files or plots. The controls, from left to right:

- **Play** - begins automatically stepping through images/plots.
- **Stop** - stops the animation.
- **Step Back / Step Forward** - goes to previous or next image/plot.
- **Loop** - toggles between looping from last image to first, and bouncing from forward to backward animation.
- **Frame rate** - selects the speed of the animation..

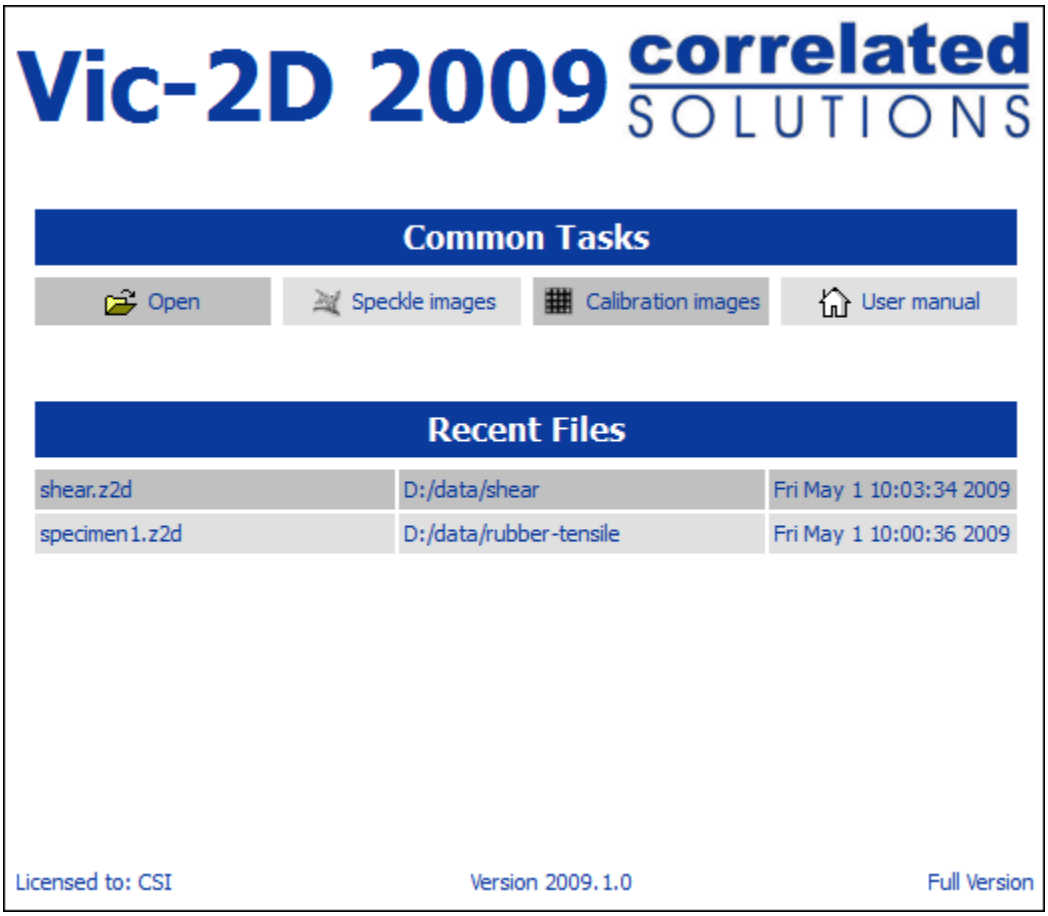
Other Functionality

In the right corner of the status bar at the bottom of the main window, the cursor position and image grey value is displayed when the mouse is moved inside the reference image or a deformed image. When mousing over contour plots, coordinates as well as the value of the current contour variable will be displayed.. On the left side of the status bar, a short description of tool buttons and menu items is displayed when the mouse moves over them.

In the list view on the left side of the main window, some functions can be activated by right-clicking. Details can be found in the appropriate sections of this menu.

The Start Page

The start page in Vic-2D gives convenient access to frequently-used tasks, recent projects, and project type selection.



Common Tasks

This section duplicates common tasks from the menu bar. Click to open a project, add speckle or calibration images, or view this user manual.

Recent Files

This section contains a list of the most recently accessed projects. Click on a filename to open the project.

Projects in Vic-2D

In Vic-2D, all the files and information associated with a test are stored in a *project*.

Initially, projects are blank. Before completing a Vic-2D analysis, the project must contain:

- Two or more speckle images , including a reference image
- One or more areas of interest

Note: Adding speckle and calibration images to the project adds them by filename reference only; they are not copied or moved on the disk.

When you run a Vic-2D analysis, the output files are stored on a disk and added (by reference) to the project file. If the project file is not saved or if the data files are manually removed, they will remain on the disk.

In addition to the items above, you can also choose to add auxiliary data references to the project file:

- Generated video clips
- Analog data files from Vic-Snap

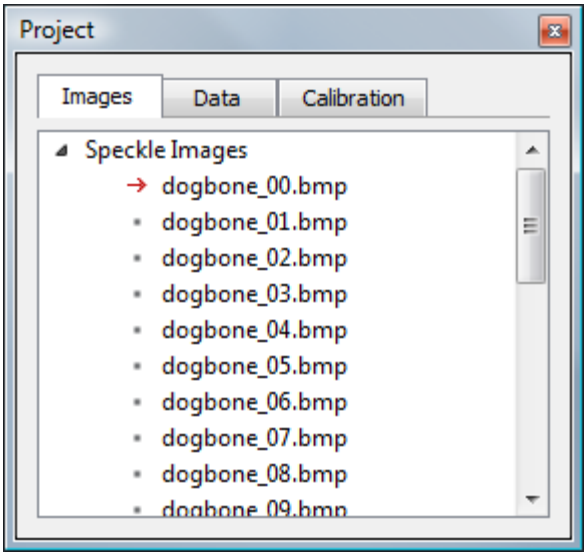
Notes

- In general, it's good practice to save project files often to avoid losing changes.
- Vic-2D 2009 uses a new .z2d project file format. Older .vic files may be opened, but not saved.
- Once a calibration is performed and saved in the project file, the calibration images may be discarded if desired. All the data calculated in the calibration routine is stored numerically in the project file.

The Project Toolbar

The plot toolbar is displayed at the left side of the work area by default. It contains information about image files, data, and calibration for the current project.

The Images Tab



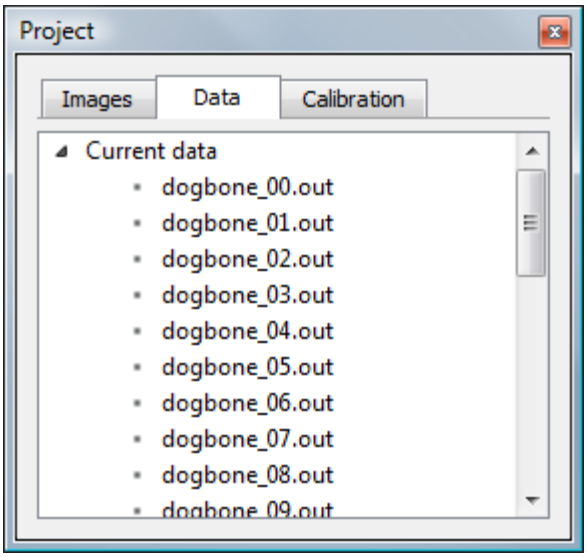
This tab shows all speckle and calibration images associated with the project.

To add speckle images, select *Images... Speckle images* from the menu bar, or click the speckle images icon on the main toolbar. The small red arrow indicates the reference image; to set an image as the reference, right click and click *Set as reference* .

To add calibration images, select *Images... Calibration images* from the menu bar, or click the calibration images icon on the main toolbar .

To remove an image or series of images, select them, right click, and click *Remove* or *Remove selected* .

The Data Tab



The Data tab lists all output data, analog data, and video files associated with the project.

All generated output files are added to the *Current data* list. Output files not associated with current speckle images are added to *Other data*. Double-click on a data file to view a plot.

Analog data from Vic-Snap is listed under *Analog data*. To add an analog data file, select *File... Add Files... Add Data Files* from the main menu. To view a spreadsheet of the data, double-click the filename.

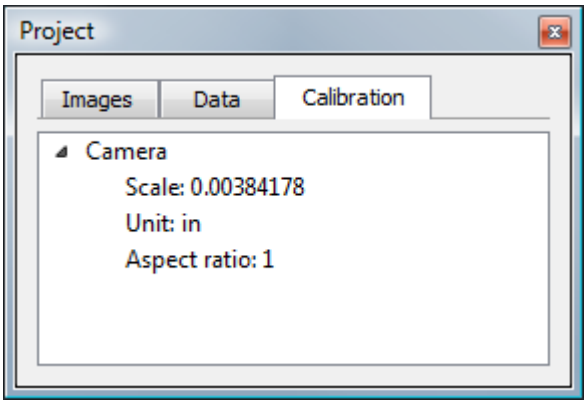
Analog Data: membrane.csv

	Time_0	Time_1	Pressure	Channel_1	Channel_2	
membrane-001_0.tif	1.208	1.213	0.0878906	1.48926	2.06543	3.(
membrane-002_0.tif	2.174	2.179	0.131836	1.05469	1.78711	2.(
membrane-003_0.tif	3.141	3.146	0.239258	0.791016	1.50879	2.3
membrane-004_0.tif	4.107	4.112	0.327148	0.629883	1.25977	2.(
membrane-005_0.tif	5.074	5.079	0.405273	0.551758	1.05957	1.7
membrane-006_0.tif	6.04	6.045	0.46875	0.527344	0.908203	1.4
membrane-007_0.tif	7.007	7.012	0.517578	0.522461	0.800781	1.2
membrane-008_0.tif	8.215	8.22	0.561523	0.537109	0.727539	1.1
membrane-009_0.tif	9.181	9.186	0.59082	0.551758	0.678711	1.(
membrane-010_0.tif	10.148	10.153	0.620117	0.581055	0.649414	0.9
membrane-011_0.tif	11.114	11.119	0.639648	0.610352	0.649414	0.8

Generated video files from animations are added to the *Video files* list. Double-click on a video to

display it in an external viewer.

The Calibration Tab



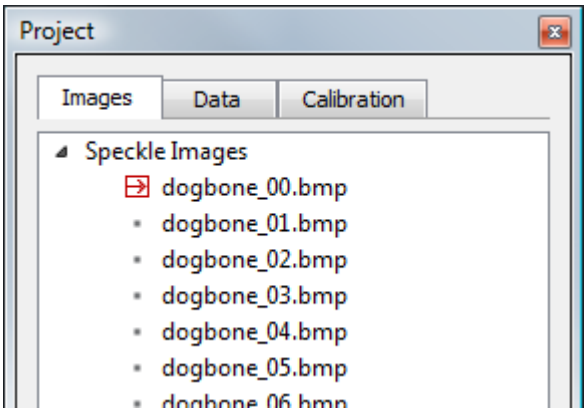
The Calibration tab displays the current 2D calibration data (scale; selected units; and aspect ration). To change the aspect ratio, select *Calibration... More... Set aspect ratio* from the main menu.

Speckle Images

In Vic-2D, speckle images are image or set of images taken of a specimen as it undergoes load or motion. You may add one or multiple speckle images by selecting the *Speckle images* entry from the *Images* menu, or by clicking the icon on the main tool bar .

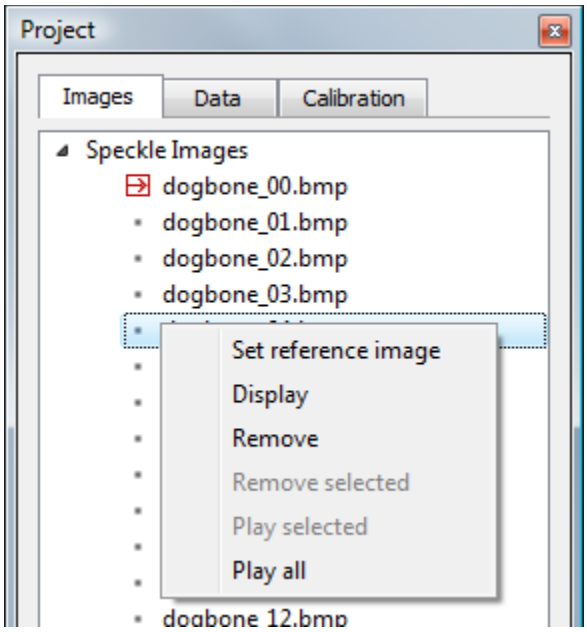
If more than 300-400 images are to be added, select *Images... Speckle image folder* to add all images from a specified folder. Each valid image file from the selected folder will be added to the project; extraneous / calibration images may then be removed. Trying to add too many images through the *Speckle images* dialog may result in an error due to operating system limitations.

After adding speckle images to the project, they will be displayed in the workspace and listed in the *Images* tab of the project bar as shown in the figure below.



Viewing Images

Deformed images can be displayed in the workspace by double-clicking on an entry in the image list view. Alternatively, clicking the right mouse button on an entry of the list view will show a popup menu providing different options, one of which is *View* .



When viewing deformed images, you can use the zoom in/zoom out entries in the *Edit* menu or the corresponding tool buttons to change the scale of the displayed image.

Animating Images

To animate speckle images, display an image and then use the controls on the Animation Toolbar to animate the sequence.

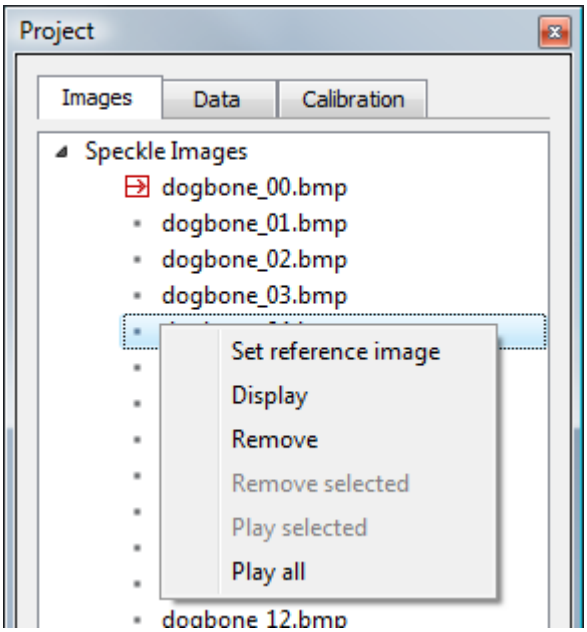
Removing Images

Calibration images can be removed by selecting one or multiple images in the list view, and right-clicking on your selection. Select *Remove* or *Remove selected* to remove images from the list.

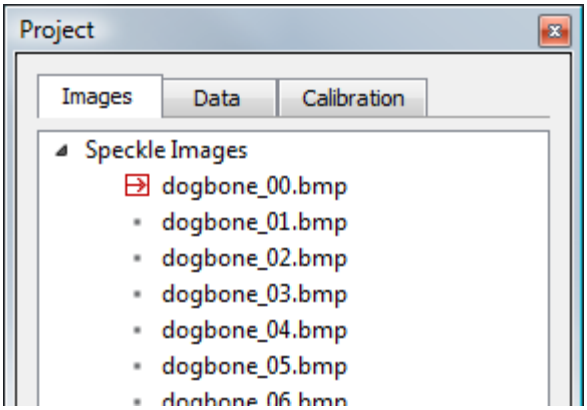
The Reference Image

The term *Reference Image* is used in this manual to describe the image of the specimen taken while no load was applied. All displacement analyses in Vic-2D are with respect to this reference image, i.e., the displacements are obtained in a Lagrangian coordinate system.

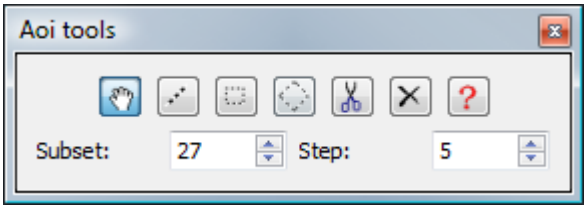
To select a reference image, right-click on it in the Speckle images list, and select *Set as reference.*



After the reference image has been selected, it will be indicated with a red arrow in the images list.



When the reference image is displayed, the AOI tool buttons and menu entries in the *Edit* menu become active.



Selecting an Area-of-Interest

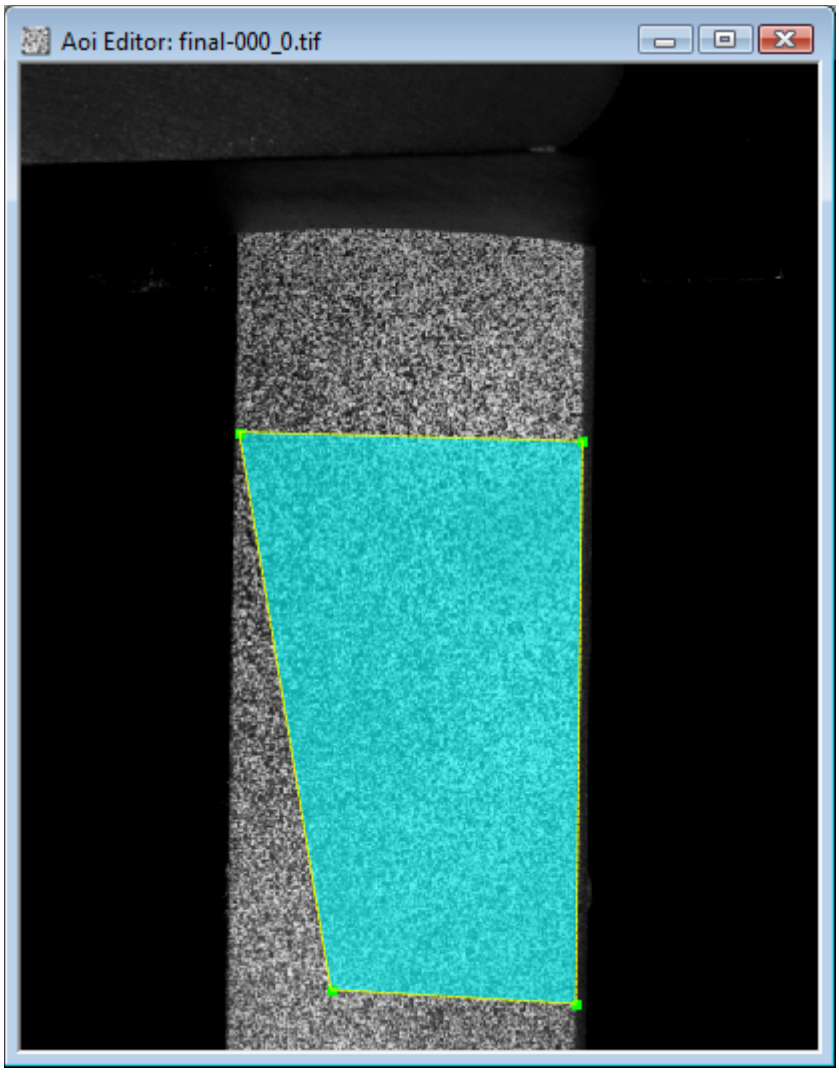
Vic-3D supports the following types of AOIs:

- **Line:** A number of points evenly spaced along a line. Note: data from line AOI's will not be visible in 2D plots because it does not comprise an area. This data may be viewed in exported files only.
- **Rectangle:** Points spaced on an even grid contained in a rectangular area.
- **Polygon:** Points spaced on an even grid contained in a polygon.

To specify a particular type of AOI, select the corresponding entry in the *Edit* menu or the appropriate button on the tool bar. The selected AOI type will be indicated by the mouse cursor.

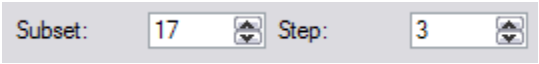
After selecting the AOI type, move the cursor to the desired position in the reference window and click the left mouse button. You can now move the mouse to the next position, e.g. the end of the line or the second corner of the rectangle. Clicking the left mouse button again will complete the AOI selection for all AOI types except polygons. For polygon selection, a double-click is used to specify the last point of the polygon.

During AOI selection, a yellow line is drawn to indicate the outline of the selection; small green squares indicate nodes. This is illustrated in the figure below.



Choosing the Subset and Step Size

The subset and step size can be selected after an area of interest is created. Both are adjusted using the spin boxes in the AOI Toolbar.



The subset size controls the area of the image that is used to track the displacement between images. The subset size has to be large enough to ensure that there is a sufficiently distinctive pattern contained in the area used for correlation.

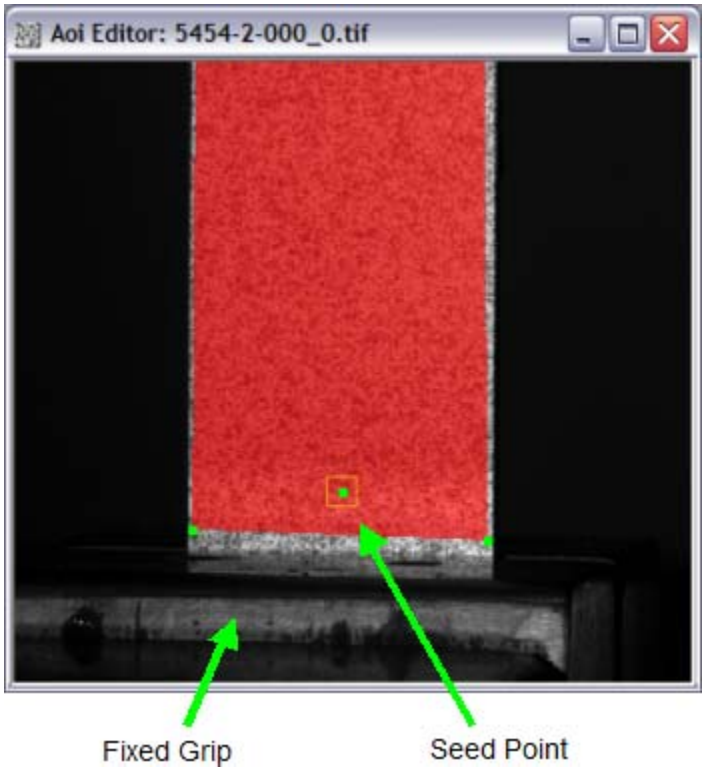
The step size controls the spacing of the points that are analyzed during correlation. If a step size of 1 is chosen, a correlation analysis is performed at every pixel inside the area-of-interest. A step size of 2 means that a correlation will be carried out at every other pixel in both the horizontal and vertical direction, etc. Note that analysis time varies inversely with the square of the step size; i.e., a step size of 1 takes 25 times longer to analyze than a step size of 5.

The Seed Point

The term *Seed Point* is used to refer to the point in the reference image where the correlation is started. The correlation algorithms use the results from the seed point to obtain an initial guess for the second point analyzed and continue in this manner until all points in the AOI are analyzed.

For rectangular and polygon AOIs, the seed point can be moved to a user-specified location in the AOI. To move the seed point, select the 'Hand' tool, or select *Edit... Pan/Select* from the menu bar. Then, mouse over the seed point; the cursor will change to indicate node movement. Click and drag to place the seed point.

The placement of the seed point can greatly influence the amount of work required to select an initial guess . Ideally, the seed point should be placed in the area of the image that underwent the smallest amount of motion during the test. An example is illustrated in the figure below.



In this example, the seed point should be placed on the side of the image closest to the fixed grip of the test frame, and on the center-line of the specimen. This way, even as the test progresses and the specimen becomes more deformed, the start location for the correlation will experience relatively small motions.

Editing AOIs

To edit an existing AOI, select the Pan/Select tool. Mouse over any of the green nodes in your AOI; the mouse cursor changes to indicate node movement. Click and drag to move.

Cutouts

For rectangular and polygon AOIs, the scissors tool can be used to cut areas from the AOI. This feature is most commonly used if the specimen has cracks, holes, or other areas where correlation is impossible.

To cut an area from an AOI, click the scissors button on the tool bar or select *Edit... Cut region*. The selection of the area to be cut works like selecting a polygon AOI, i.e., corner points of a polygon can be added by single-clicking the left mouse button, and the last point is specified by a double-click. Once the cut is complete, new nodes are added to your AOI; these may be moved like other nodes.

Hints

- Use the scroll wheel to adjust the size of the image.
- When using multiple AOIs for one image, click on an AOI with the pan/select tool to activate it.
- During AOI selection, the image can be scrolled by moving the mouse outside the reference image window. This will cause the image to autoscroll if the image does not fit on the display.
- You can use the Undo/Redo buttons to undo AOI selection and other operations. The Undo/Redo buttons in the *Edit* menu will indicate what changes can be undone/redone.

Initial Guess Selection

In Vic-2D 2009, initial guesses will be needed very rarely. Some instances where they may still be necessary include:

- Very large motions between imags
- Very fine or indistinct speckle patterns

In the absence of these conditions, you can generally run the correlation immediately after selecting an AOI. If the correlation fails or runs very slowly, an initial guess may be needed.

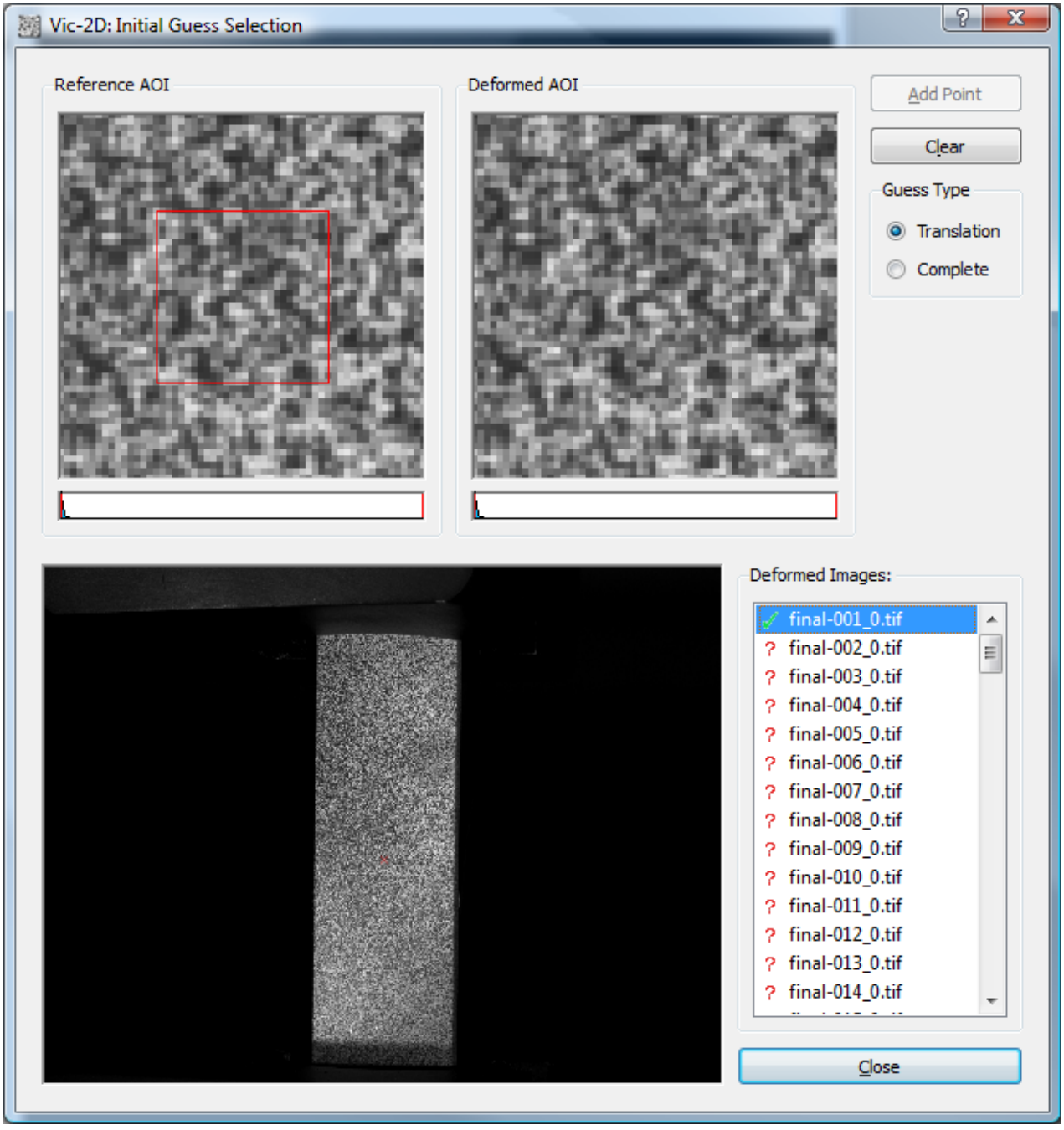
Placing the seed point

Generally, it is best to place the seed point of the AOI in the area of the image that undergoes the least amount of motion during the test. For instance, if a specimen is tested in a tensile frame, the seed point should be placed as close to the stationary grip as possible. Placing the seed point this way will help ensure fully automatic correlation.

For very large transformations or rotations, it can be very helpful to place fiducial marks on the surface. This can be integrated into a printed pattern (see below) or simply drawn on the surface with a marker. These marks may be located much more easily than the random pattern especially if, i.e., one image is rotated 180 degrees from the other.

Selecting an initial guess

The initial guess dialog can be accessed through the *Edit* menu or the tool button in the AOI toolbar. The initial guess dialog is shown below.



The area surrounding the seed point in the reference image is displayed in the box labeled *Reference AOI*. Next to it, the pattern in the deformed image is displayed in the box labeled *Deformed AOI*. The image in the bottom left of the dialog shows the deformed image. Each of these can be zoomed using the mouse wheel.

A histogram control is provided for the reference and deformed images. Adjust the red bars to control image balance; this can be useful for finding detail in very dark images. Double click the histogram to automatically set/reset the limits.

The listbox on the bottom right can be used to select the deformed image for which the initial guess is being provided. If a green checkmark appears next to an image when activated, the initial guess has been located automatically and no further intervention is required.

Selecting corresponding points

To select corresponding points in the reference and deformed image, the red cross in the bottom left image has to be placed in the area of the deformed image that corresponds to the area around the seed point in the reference image. This can be done by clicking and moving the mouse in the bottom image. The scroll wheel can be used to zoom in and out; hold Shift and drag in the bottom image to pan. The image in the *Deformed AOI* box is updated to reflect the location in the bottom image. Once the *Reference Aoi* and *Deformed Aoi* images show the same region, common points can be selected.

Translation and Complete Guess

An initial guess can be specified for the translation components of the displacement only, or for the complete deformation including the partial derivatives of the displacement. The latter will only be neccessary in cases where the strains and/or rotations are very high.

Translation Guess

Follow the steps below to specify a translation guess:

- Select a common point in the *Reference Aoi* and *Deformed Aoi* by clicking the mouse.
- Click the *Add Point* button, or click the right mouse button. The point pair turns yellow, and a guess is calculated. The icon in the file list will change to a green check to indicate that an initial guess has been selected for the current image.
- Optionally, repeat the first two steps for more corresponding points; the results will be an average of all selected points. This can give higher accuracy but is usually not necessary.
- If necessary, repeat this procedure for all deformed files shown in the file list.

Complete Guess

Follow the steps below to specify an initial guess that includes estimates for the partial derivatives of the displacement (only necessary for very large strains and/or large rotations):

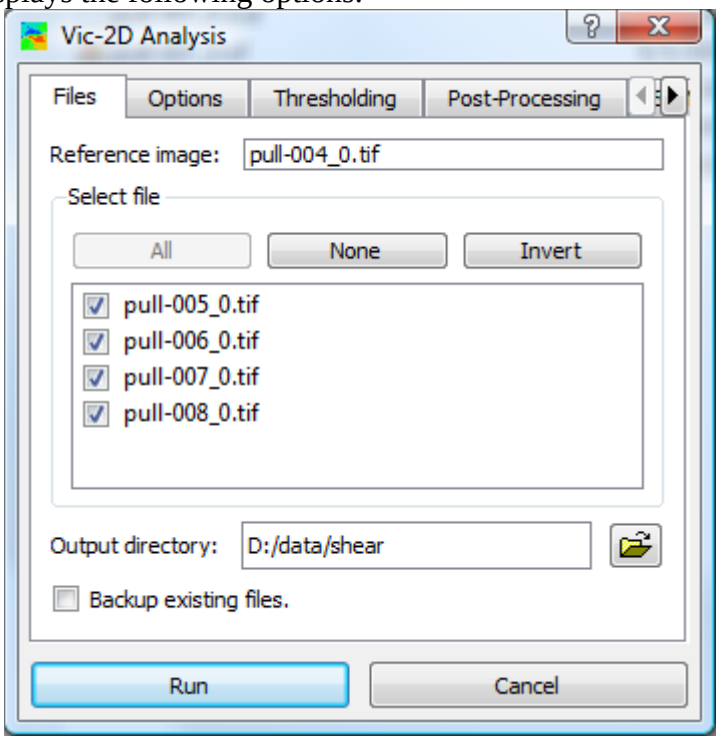
- Check the *Complete* item in the *Guess Type* check box.
- Select a common point in the *Reference Aoi* and *Deformed Aoi* by clicking the mouse.
- Click the *Add Point* button or click the right mouse button.
- Repeat for at least two more points. Note that the points should not be co-linear, i.e., try to select three points that make a triangle.
- Once at least three points are added, the icon in the file list will change to a green check to indicate that an initial guess has been selected for the current image.
- If necessary, repeat this procedure for all deformed files shown in the file list.

Running the Correlation

To run the displacement analysis, select the *Run Correlation* entry from the *Data* menu, or press the button on the tool bar.

The File Tab

The tab on the dialog displays the following options:



Selecting Images

The deformed images to use for correlation analysis can be selected from the list box on the dialog. Selected images are indicated by a check mark. Above the list box, buttons are available to select/deselect all image files contained in the list box. To select 1 data file from from every 2, 5, 10, or *n* , right-click in the file list and choose the desired option.

If no images are selected, only the reference image is analyzed.

Backup copies

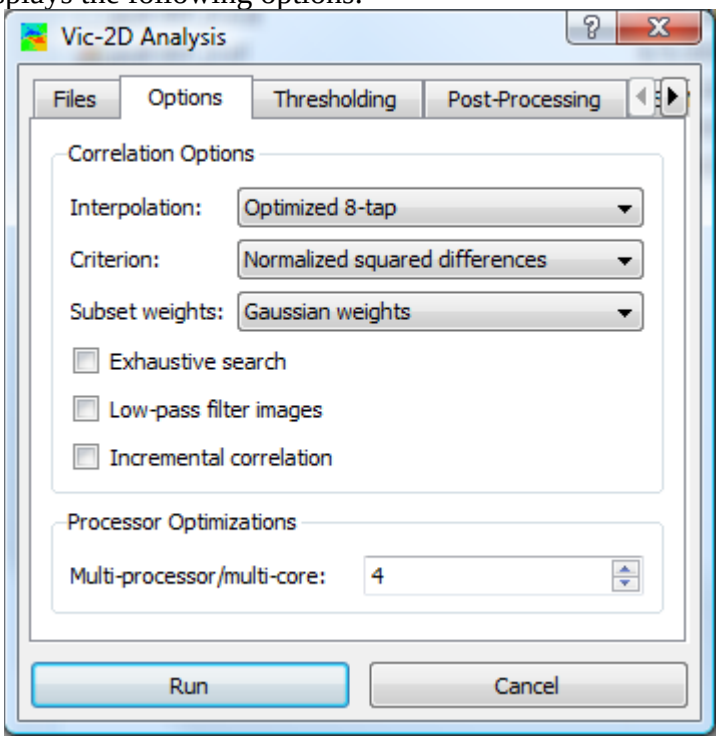
When this option is checked, Vic-3D will make backup copies of existing output files by replacing their file extension with *bak.*

Output directory

The directory in which the output files are stored can be selected by clicking the folder icon.

The Options Tab

The tab on the dialog displays the following options:



Interpolation

To achieve sub-pixel accuracy, the correlation algorithms use gray value interpolation, representing a field of discrete gray levels as a continuous spline. Either 4-, 6-, or 8-tap splines may be selected here.

Generally, more accurate displacement information can be obtained with higher-order splines. Lower-order splines offer faster correlation at the expense of some accuracy.

Criterion

There are three correlation-criteria to choose from:

- Squared differences: Sensitive to any lighting changes; not generally recommended.
- Normalized squared differences: Insensitive to scale in lighting (i.e., deformed subset is 50% brighter than reference.) This is the default and usually offers the best combination of flexibility and results.
- Zero-normalized squared differences: Insensitive to offset and scale in lighting (i.e., deformed subset is 10% brighter plus 10 gray levels.) This may be necessary in special situations.

Subset weights

This option controls the way pixels within the subset are weighted. With Uniform weights, each pixel within the subset is considered equally. Selecting Gaussian weights causes the subset matching to be center-weighted. Gaussian weights provide the best combination of spatial resolution and displacement resolution.

Exhaustive search

Enabling this option will cause Vic-2D to repeat a coarse search for matches after each time the correlation fails. This may result in more data recovery at the expense of vastly increased processing time.

Low-pass filter images

The low-pass filter removes some high-frequency information from the input images. This can reduce aliasing effects in images where the speckle pattern is overly fine and cannot be well represented in the image. (These aliasing effects are often visible as a moire-type pattern in the output data.)

Incremental correlation

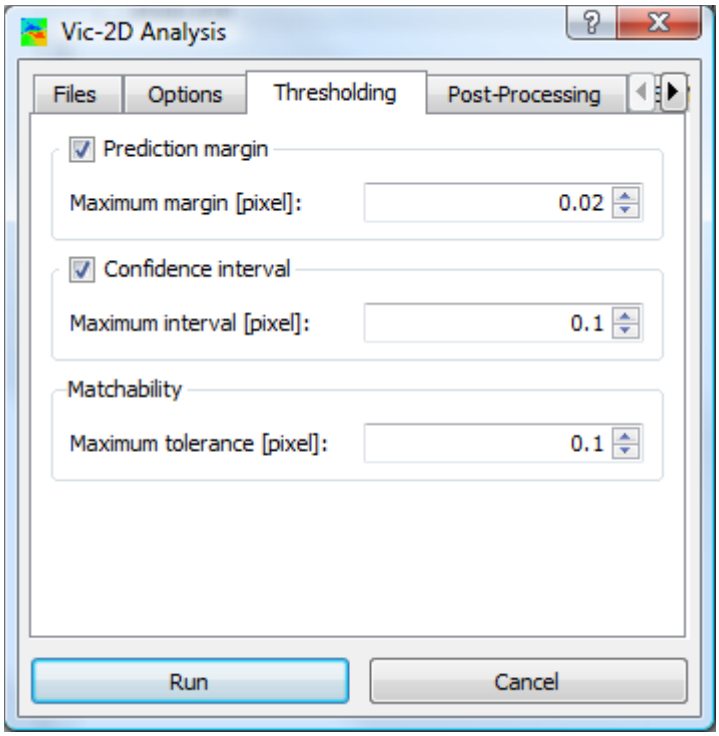
With incremental correlation, each image is compared to the previous image rather than the reference image. This can be useful in cases of pattern breakdown or extremely high strains (>100%). This comes at the expense of an increase in noise.

Processor Optimizations

This option controls the number of processors/cores Vic-3D uses for analysis. In most cases this will be correctly determined automatically by Vic-3D.

The Thresholding Tab

This tab provides options for removing any data that is bad or suspect while maximizing the amount of retained data. Four thresholding options are available. For a typical test, the default values will work very well, but when conditions are unusual or substandard (blur; debris; poor lighting; etc), some adjustment may be required.



Prediction margin

After Vic-3D analyzes the seed point, the analysis is propagated to each of its four neighbors, and so on. Each point is fed with a prediction of its approximate match. After the match is made, a *back*-prediction is calculated. If the back-prediction does not closely match the actual location of the prior neighbor, this threshold will remove the data.

Projection error

If a calculated match does not lie very close to the epipolar line, this threshold removes the data. High projection error may be caused by motion blur; a poor calibration; or cameras which are not rigidly mounted.

Confidence interval

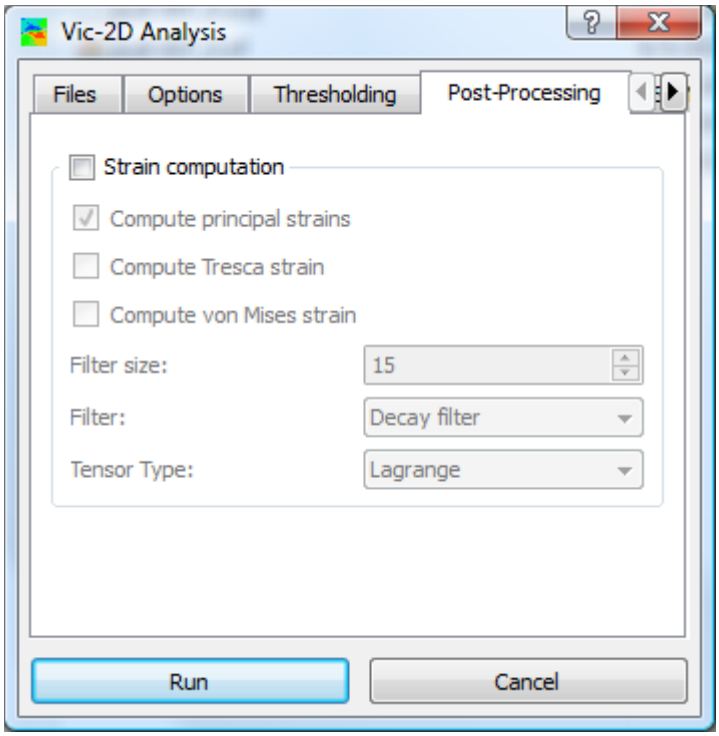
For each match, Vic-3D calculates a statistical confidence region, in pixels, using the covariance matrix of the correlation equation. If the confidence region exceeds this threshold, the data will be removed.

Matchability

This option automatically removes subsets that show a very low contrast, i.e, subsets that don't contain very much information. Increase this value to remove more data; reduce to retain more data, i.e., if lighting conditions were poor.

The Post-Processing Tab

The tab on the dialog displays the following options:

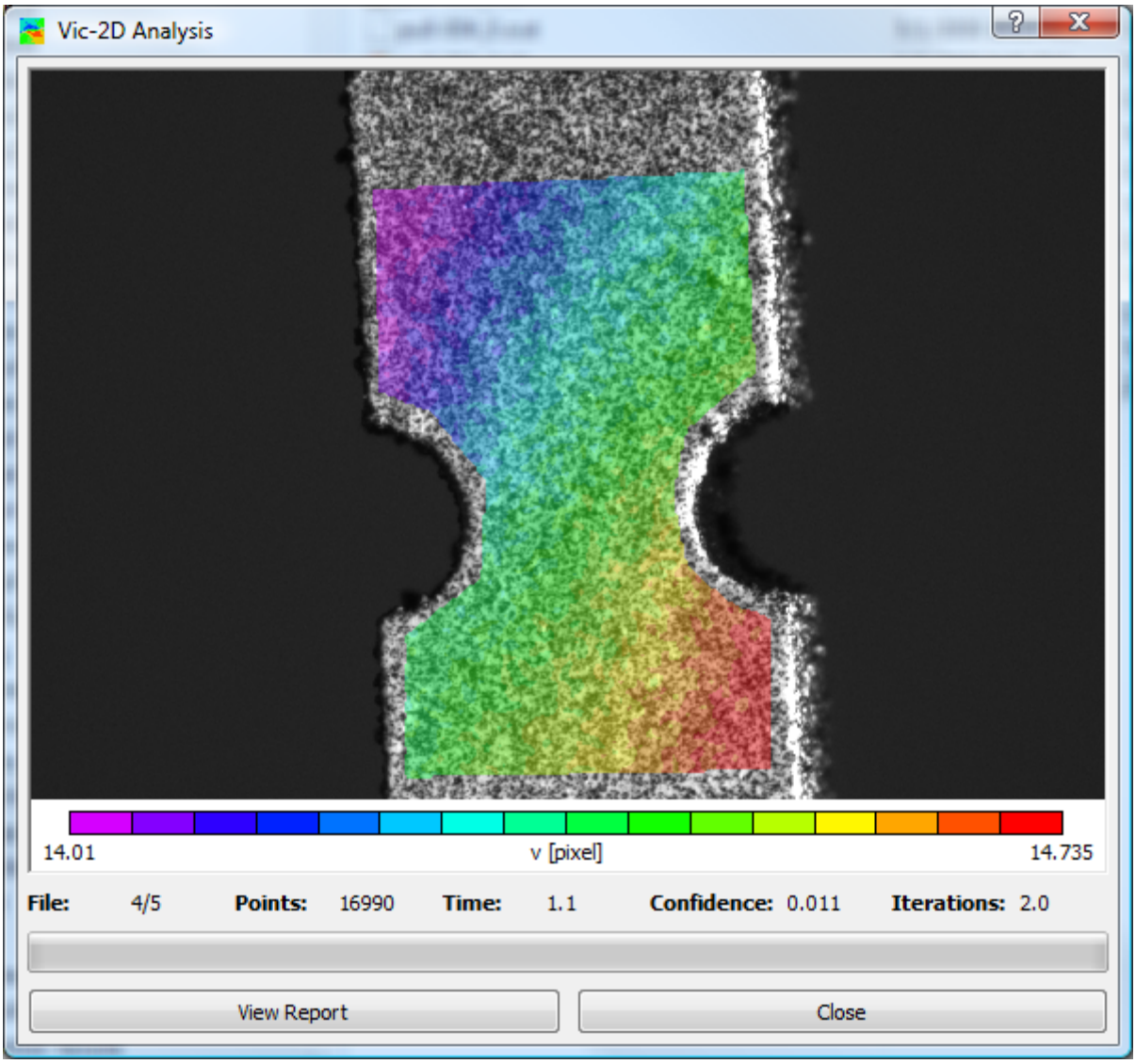


Strain Computation

Checking this option performs a strain computation as each image is processed; results can be viewed in the preview.

Correlation Results

After you begin the correlation, the following window appears.



The window contains an overview of correlation progress and reults.

File - the progress and total number of files to analyze.

Points - the number of data points calculated for the image.

Time - The amount of time spent on correlation analysis in seconds.

Error - a measure of correlation accuracy (specificially, epipolar projection error). A high number indicates possible problems with calibration or camera synchronization.

Iterations - a measure of how many possible matches were searched for each point.

Progress bar- indicates the progress of each individual file as it is correlated.

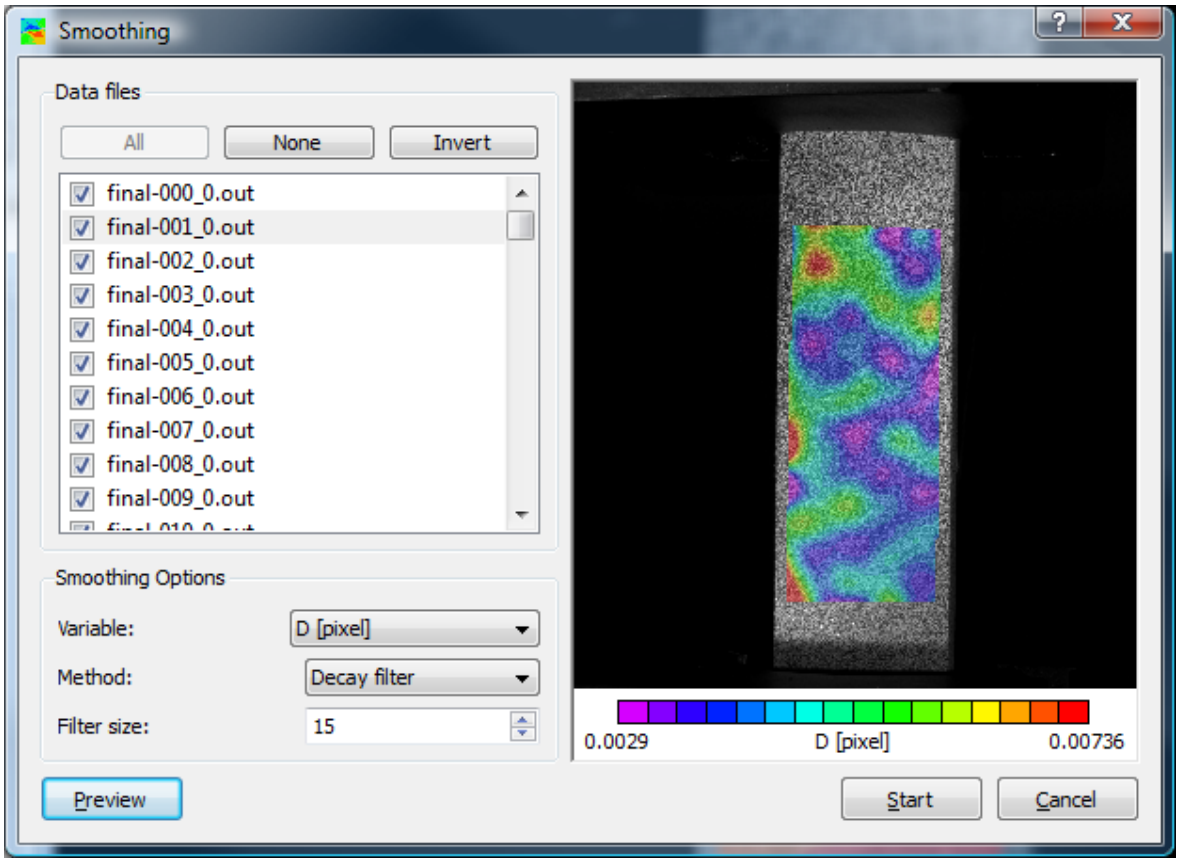
This window also contains a preview of the output data. This data may be view in 2D and 3D and manipulated as with a standard plot.

When the analysis is complete, you may click View Report to see a summary of the above data.

For more information on interpreting correlation results and troubleshooting errors, please contact Technical Support.

Smoothing data

To calculate strain for a set of data, select *Data... Postprocessing options... Smooth variable* from the main menu.



Selecting Data Files for Processing

The available data files are displayed in the *Data Files* list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files, while *Invert* reverses your selection.

Preview

To view the effects of the calculation for a single data file, highlight the file and click the *Preview* button.

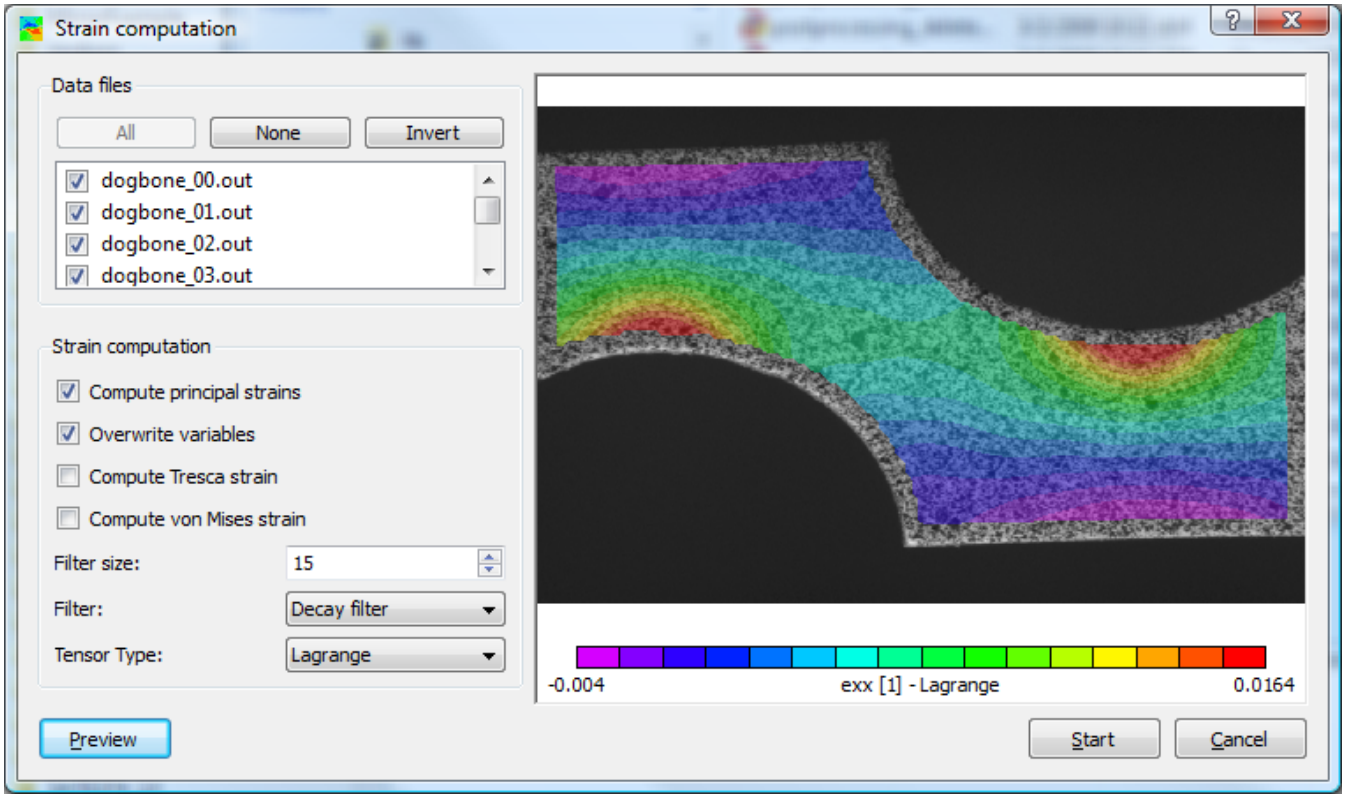
Filter size/type

Calculated strains are always smoothed using a local filter. The *Method* box allows selection of a smoothing method. The decay filter is a 90% center-weighted Gaussian filter and works best for most situations; the box filter is a simple unweighted averaging filter.

The *Filter size* box controls the size of the smoothing window. Since the filter size is given in terms of data points rather than pixels, the physical size of the window on the object also depends on the step size used during correlation analysis.

Strain Calculation

To calculate strain for a set of data, select *Data... Postprocessing options... Calculate strain* from the main menu.



Selecting Data Files for Processing

The available data files are displayed in the *Data Files* list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files, while *Invert* reverses your selection.

Preview

To view the effects of the calculation for a single data file, highlight the file and click the *Preview* button.

Compute principal strains

Check this box to add principal strains and principal strain angle to the calculated output data.

Overwrite variables

Check this option to overwrite any existing strain calculations. If this box is clear, more data fields will be added to the output data set each time strain is calculated.

Compute Tresca/von Mises strain

Select these options to compute the Tresca/von Mises strain criterion along with the strain tensor calculation.

Filter size/type

Calculated strains are always smoothed using a local filter. The *Filter* box allows selection of a smoothing method.

The decay filter is a 90% center-weighted Gaussian filter and works best for most situations; the box filter is a simple unweighted averaging filter.

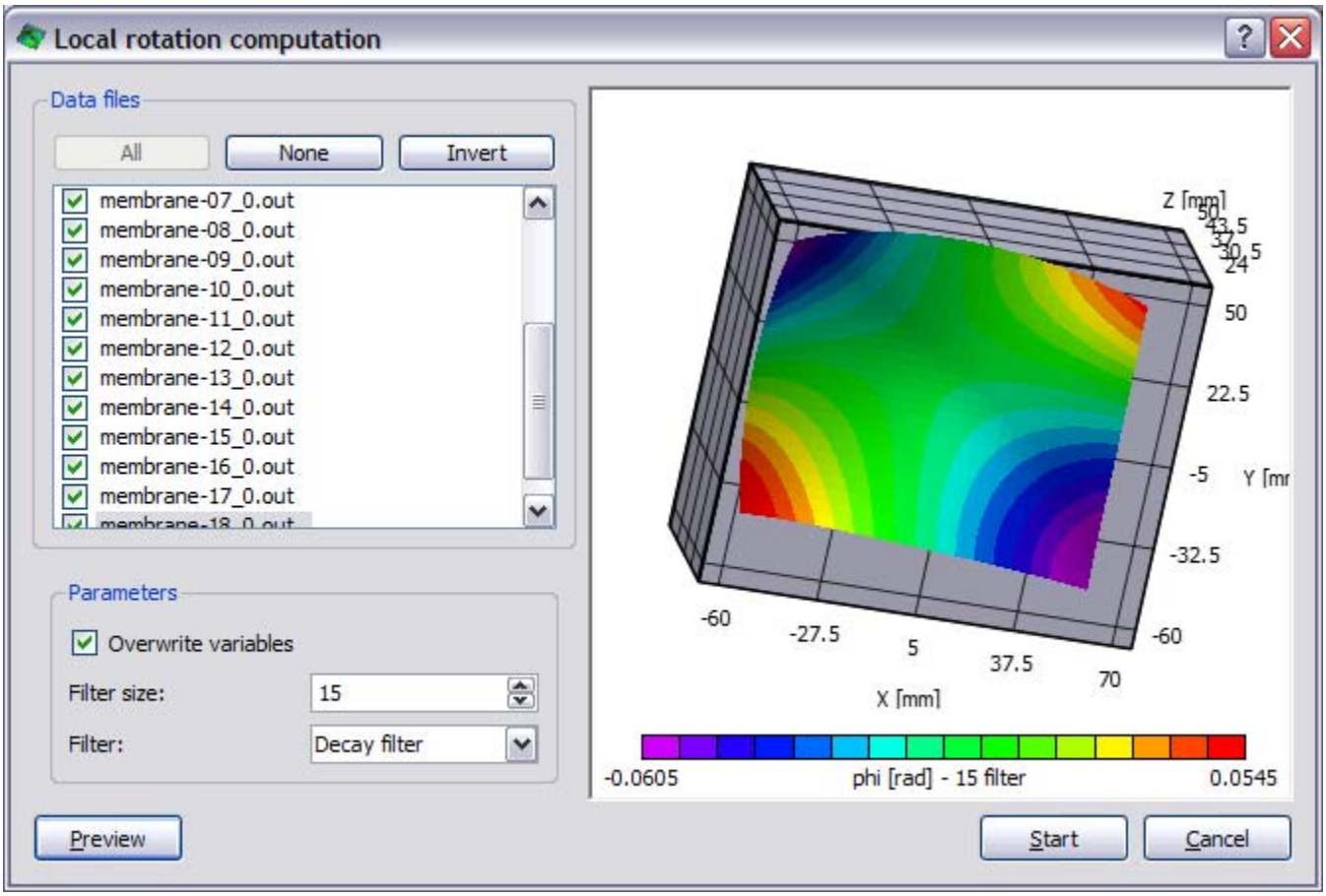
The *Filter size* box controls the size of the smoothing window. Since the filter size is given in terms of data points rather than pixels, the physical size of the window on the object also depends on the step size used during correlation analysis.

Tensor type

Select the desired strain tensor. The default is Lagrangian finite strain.

Rotation Calculation

To calculate local in-plane rotation for a set of data, select *Data... Postprocessing options... Calculate in-plane rotation* from the main menu.



Selecting Data Files for Processing

The available data files are displayed in the *Data Files* list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files, while *Invert* reverses your selection.

Preview

To view the effects of the calculation for a single data file, highlight the file and click the *Preview* button. You may view the plot in 2D or 3D as with a standard data plot.

Overwrite variables

Check this option to overwrite any existing rotation calculations. If this box is clear, more data fields will be added to the output data set each time rotation is calculated.

Filter size/type

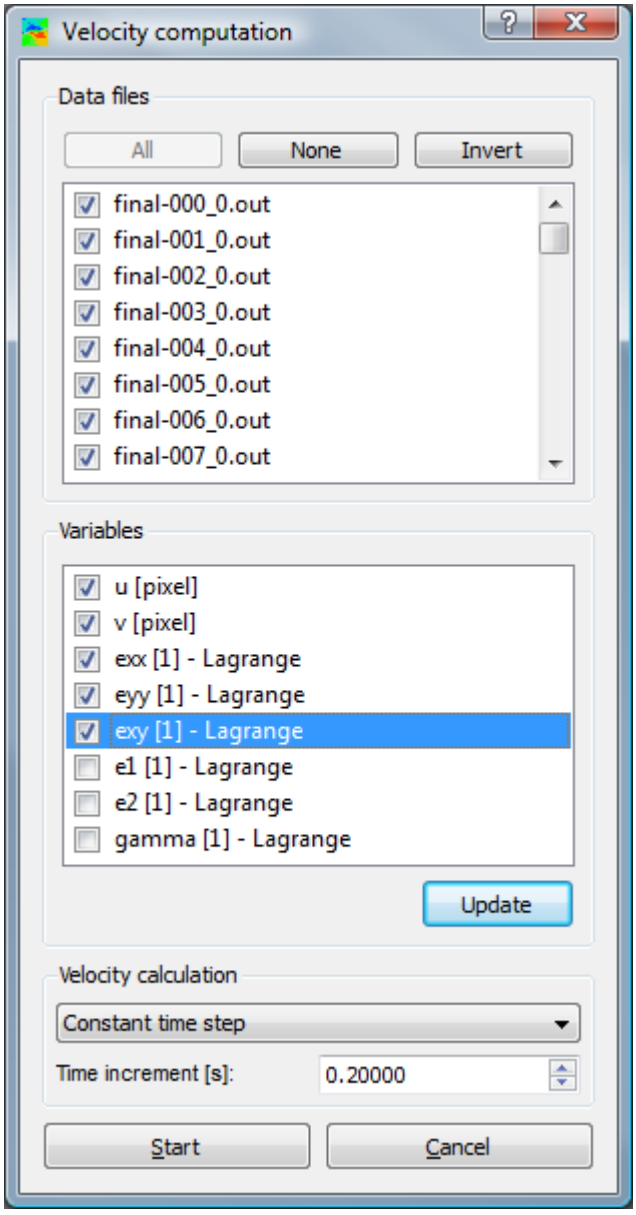
Calculated strains are always smoothed using a local filter. The *Filter* box allows selection of a smoothing method. The decay filter is a 90% center-weighted Gaussian filter and works best for most situations; the box filter is a simple unweighted averaging filter.

The *Filter size* box controls the size of the smoothing window. Since the filter size is given in terms of data points rather than pixels, the physical size of the window on the object also depends on the step size used during correlation analysis.

Calculating Velocity

Vic-2D can calculate rates for displacement and strain, using either a specified time interval or time retrieved from a .CSV log file.

Once the displacement fields have been calculated from the speckle images, velocities may be calculated by selecting the *Calculate Velocity* entry on the *Data* menu. (If strain rates are desired, strain should be calculated before opening the *Calculate Velocity* dialog.) This will display the dialog shown in the figure below.



Data File Selection

The available data files are displayed in the list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files; the *Invert* button inverts

the selection.

Velocity Calculation

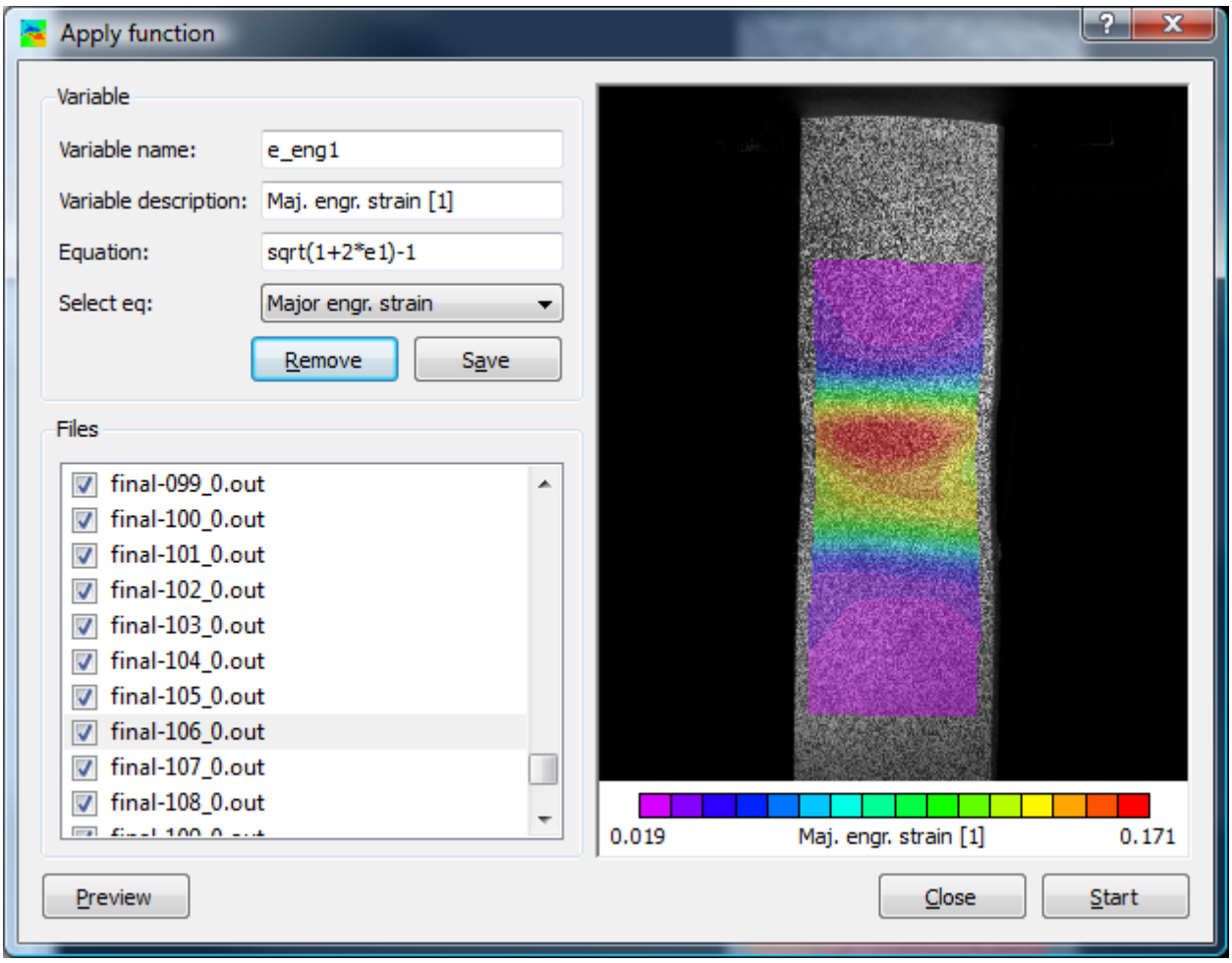
If a Vic-Snap .CSV log file exists for the project, you may select "Time From File" from the dropdown and select the file, if necessary. Otherwise, select "Constant Time Step" and enter the known time increment, or select "Constant Frame Rate" to enter a known frame rate, for, i.e., a high-speed camera.

Click Start to begin; the progress bar will indicate completion. For each strain and displacement variable in the dataset, a derivative in time will be added and can be viewed as a contour overlay.

Applying Functions to Data

Vic-3D supports the generation of new variables based on equations applied to the data. This feature can be used, for instance, to compute engineering strains from Lagrange strains, to compute stresses from strains or to compute thinning of a strained specimen of known thickness based on the Poisson's effect or volume conservation during plastic deformation.

To apply function to a data sequence, select *Data... Postprocessing options... Apply function* from the main menu.



Variable name and description

Enter a unique label for the variable name, e.g., *sigma1* for the major stress, and an appropriate description in the description field. Note that the description will be used in contour legends.

Equation

The formula to be applied to the data can be entered in the equation field. The equation is applied to each data point contained in each data file. The variables present in the data file can be accessed in the equation by their names. Not that variable names are case sensitive, e.g., *X* is the global coordinate and *x* refers to the pixel coordinate. For a description of functions and operators that can be used in equations, please see the equation format description.

If you are unsure what variables are contained in the data file, you can quickly obtain a listing of variables in the following manner. First, enter a variable name known to be present in the data file in the equation field, e.g., *x* and then press *Preview*. You can now obtain a listing by right-clicking in the plot and accessing the *Contour variables* listing.

Storing and Retrieving Equations

Equations can be stored and reused. To retrieve a previously stored equation, simply select the equation from the drop-down menu labeled *Select eq.*.

To save an equation for later use, press the *Save* button after entering the equation, variable name and description. The software will prompt for a label to identify the equation. It is recommended to test the equation by using the *Preview* button before saving it.

Stored equations can also be removed. Simply select the equation you wish to remove from the drop-down menu and then press the *Remove* button.

Selecting Data Files for Processing

The available data files are displayed in the list box on the bottom left of the dialog. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files, while *Invert* reverses your selection.

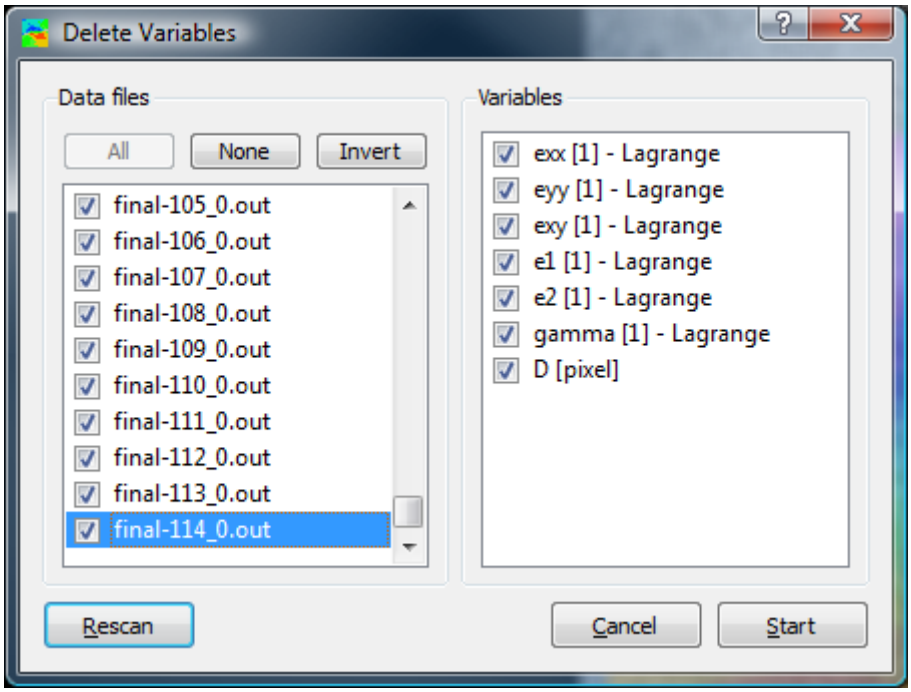
Preview

To view the effects of the calculation for a single data file, highlight the file and click the *Preview* button. You may view the plot in 2D or 3D as with a standard data plot.

Deleting Variables

User-generated variables can be deleted from data files. **Note:** Use this functionality with caution. Once removed, variables cannot be restored other than by reprocessing.

To remove variables from data files, select *Data... Postprocessing options... Map external data* from the main menu.



Selecting Data Files for Processing

The available data files are displayed in the list box on the left of the dialog. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files, while *Invert* reverses your selection.

Selecting Variables

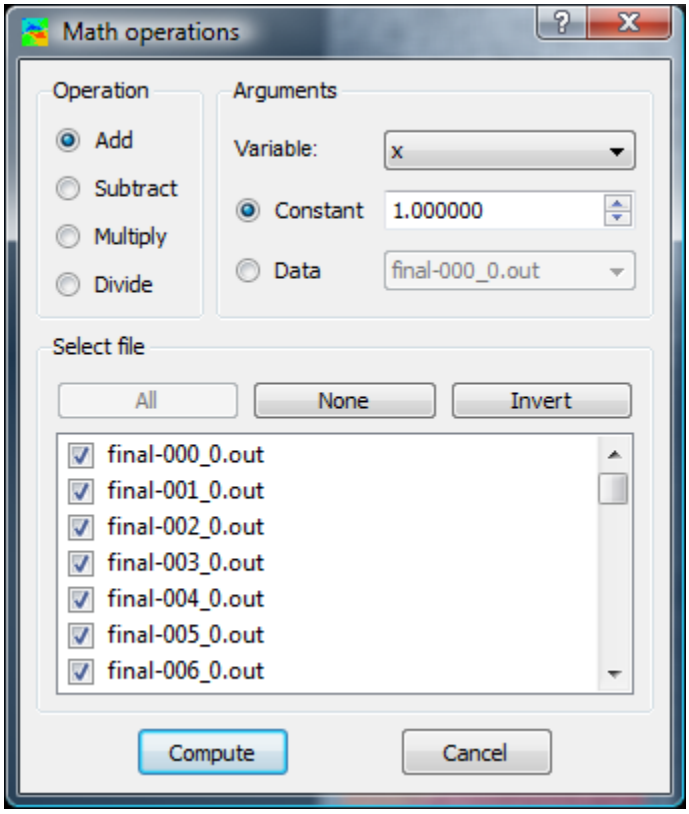
The available variables are listed in the list box on the right of the dialog. Note that only user-generated variables can be deleted. Select the variables you wish to remove by clicking on the variable name. This will toggle a check mark indicating whether the variable will be removed or not.

Rescanning Variables

If the data files do not all contain the same variables, the variable you are trying to remove may not appear in the list box when the dialog is shown. In this case, highlight the data file that contains the variable you wish to remove in the data file list box by clicking on it. Then, press the *Rescan* button to repopulate the variable list box based on the variables contained in the selected data file.

Math Operations

The *Math operations* dialog allows manipulation of output data by basic math operations. Open this dialog by selecting *Data... Math Operations* from the main menu bar.



Data File Selection

The available data files are displayed in the list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files; the *Invert* button inverts the selection.

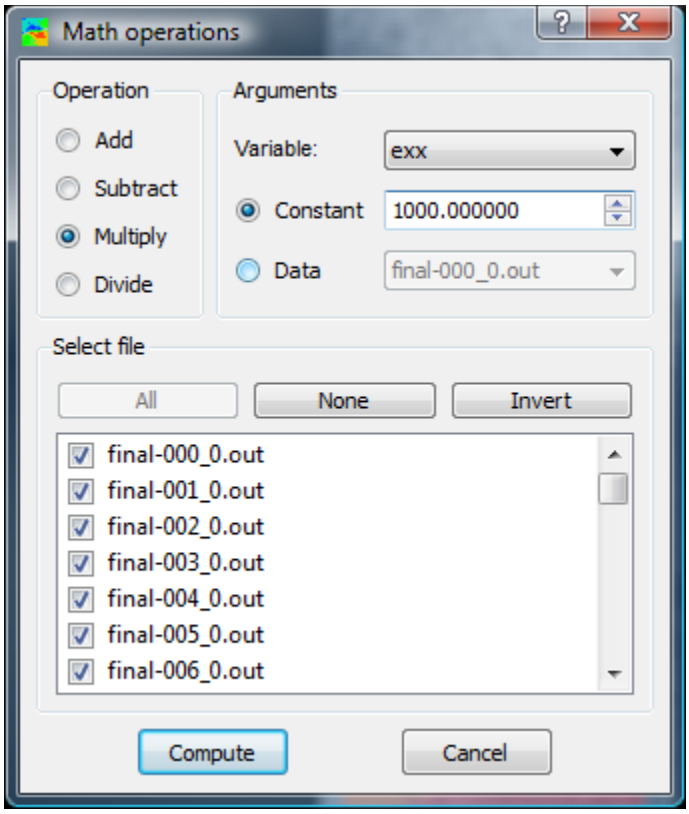
Operation

Choose Add, Subtract, Multiply, or Divide to perform the specified operation.

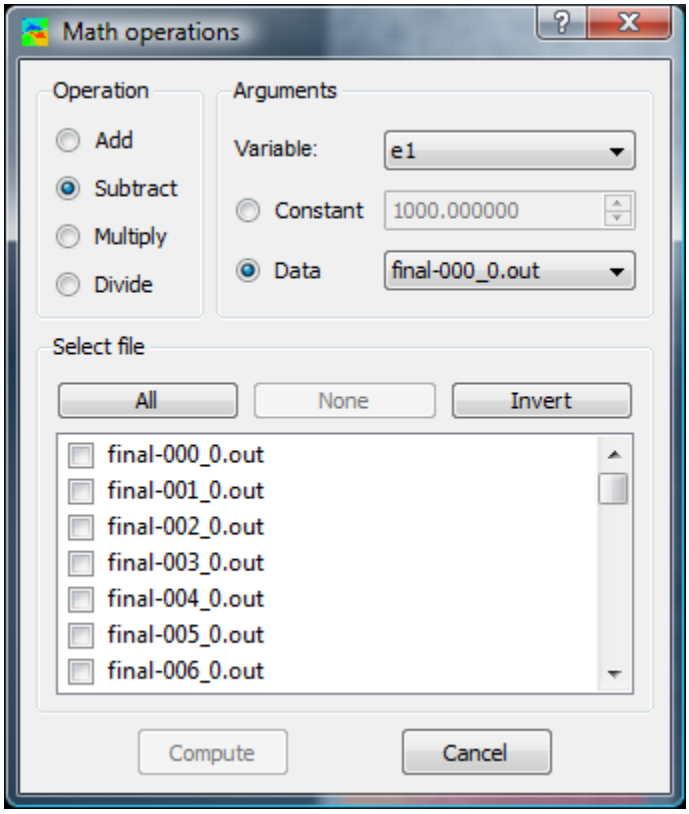
Arguments

The *Variable* box is used to select the variable to operate on. Any variable in the data set may be selected.

To use a constant argument, select the *Constant* radio button and enter the value. For example, the selections below will multiply the x-strain value from each data file by 100.



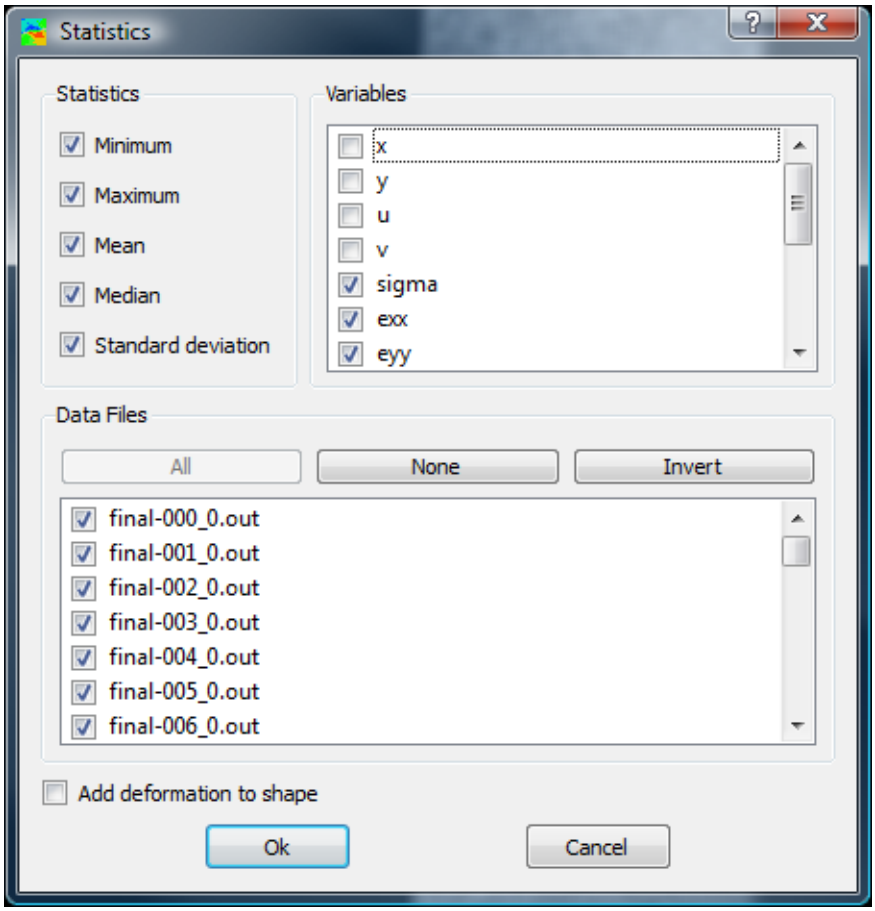
To use the data from an output file, click *Data* and select a data file. For example, the selections below will subtract the first principal strain from the first data file, from all data files.



Click Start to begin; the progress bar will indicate completion. For each strain and displacement variable in the dataset, a derivative in time will be added and can be viewed as a contour overlay.

Calculating Statistics

To export statistics for calculated variables and data files, select *Data... Statistics* from the main menu bar.



Statistics

Check the desired item to include or exclude the statistic from the output file.

Variables

Check the desired variables to add them to the calculation. By default, all metric variables are included, while correlation and pixel variables are excluded.

Data File Selection

The available data files are displayed in the list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files; the *Invert* button inverts the selection.

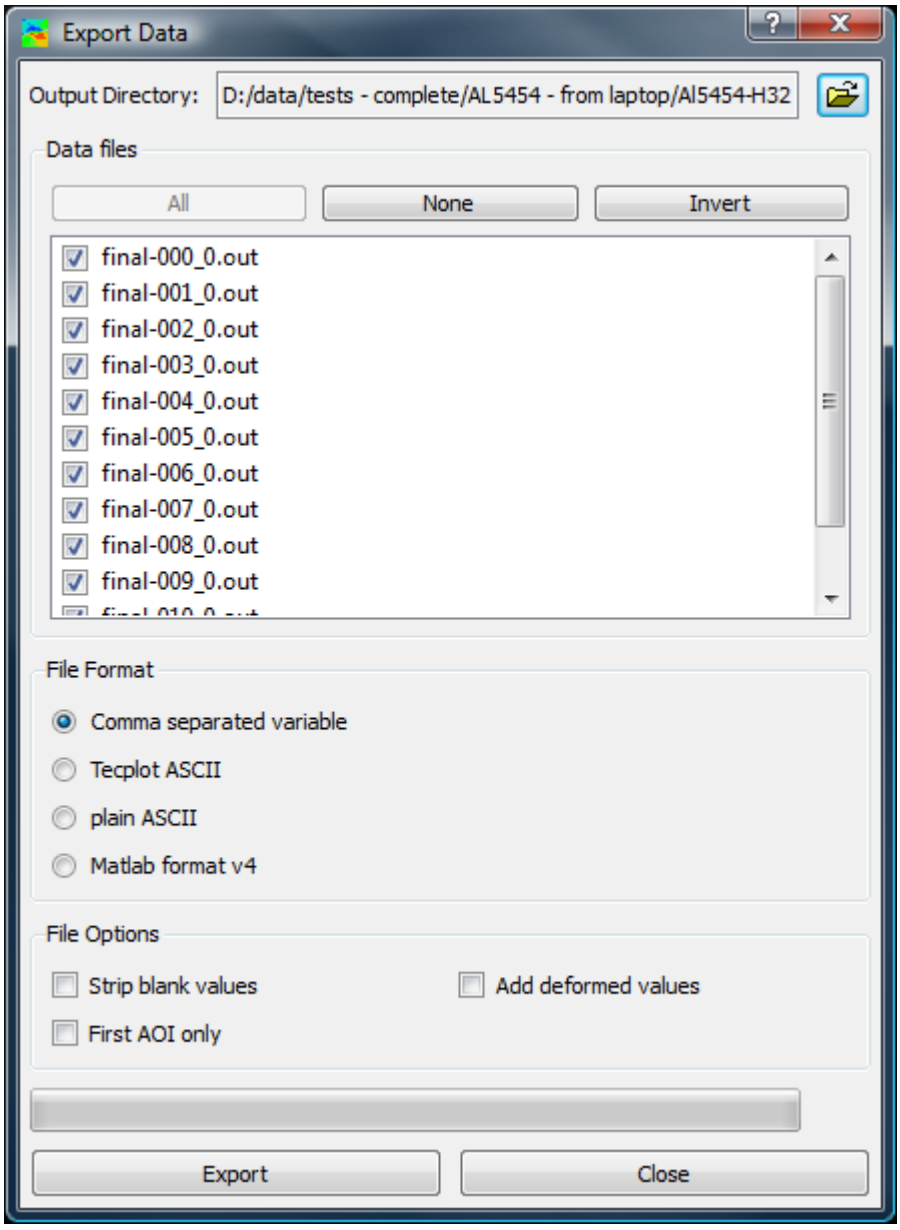
Exporting

To complete the calculation, click *Ok*. You will be prompted for a filename, and the data will be exported as a .CSV file.

Exporting Data

For efficient file access, Vic-2D stores results in a binary data file format. To use the data with other programs for post-processing and plotting, the data can be exported by selecting the *Export* item from the *Data* menu.

The dialog shown below will be displayed.



Selecting Files for Exporting

The available data files are displayed in the list box. To select which files to export, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files.

File Formats

The data files can be exported to the following formats:

Comma-Separated Variable

Data entries are separated by commas. This format is understood by most spreadsheet programs and plotting packages. Variable names are stored in the data file as comma-separated strings in quotation marks. Exported files will have the extension *csv*.

Tecplot

Used for plotting the data with *Amtec's* (www.amtec.com) plotting program *Tecplot(TM)*. Exported files will have the extension *dat*.

Plain ASCII

This format is plain, space-delimited ASCII text data with one data point per line. Note: There are no variable names in the data file, and data from different AOIs is concatenated. Exported files will have the extension *txt*.

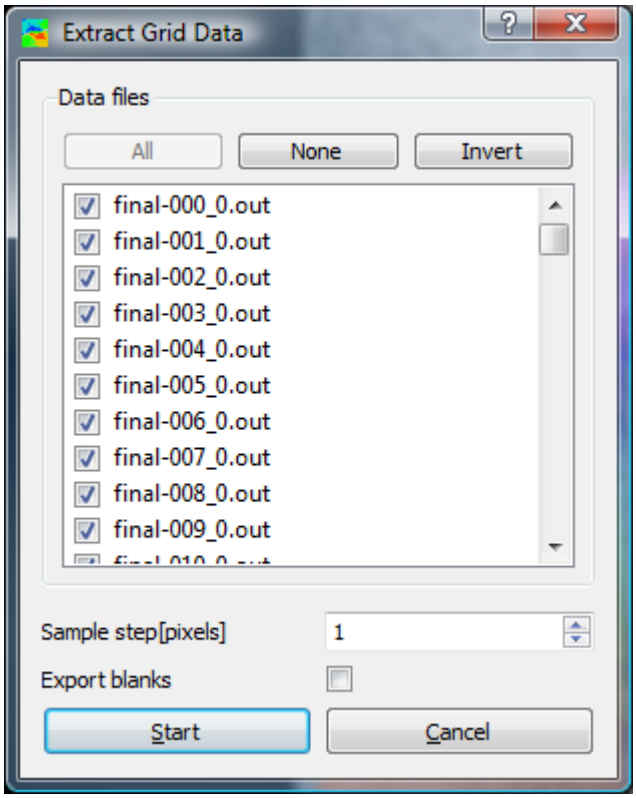
Matlab V4

This format provides compatibility with Matlab and many other programs capable of reading Matlab files. Note that if multiple AOIs are present in a datafile, unique names for each of the matrices are generated by appending increasing numbers to the variable names. For instance, the X-coordinate for the first AOI will appear as *X* in the matlab file, and for the second AOI it will appear as *X_0* and so forth.

If none of the available file formats fit your needs, please contact support@correlatedsolutions.com. We will gladly implement data exporting to a format that best suits your needs.

Exporting Grid-Based Data

This option can be used to export your data, sampled at regular intervals spatially and for each data file, to a single text file. To begin, select *Export Grid Data* from the *Data* menu.



Data File Selection

The available data files are displayed in the list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files; the *Invert* button inverts the selection.

Options

To change the sample interval in pixels, adjust the *Sample step* value. A value of 1 will sample every pixel; higher values will result in a sparser data set.

To export blank values to the output file, with a value of 0, check the *Export blanks* box. If this box is cleared, blank data points will not be present in the output file.

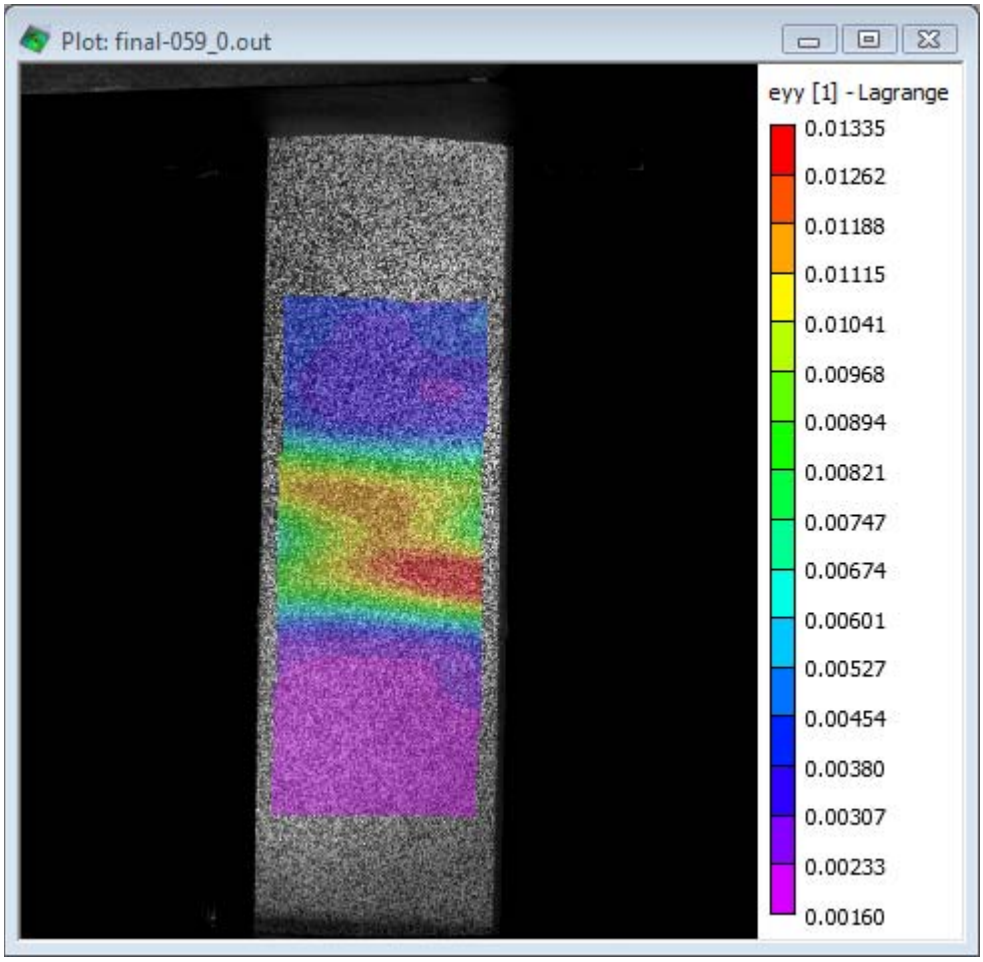
Extracting Data

To begin, click *Start*. You will be prompted for an output .csv file name. A progress bar will appear; when extraction is complete, the dialog will close.

Plots

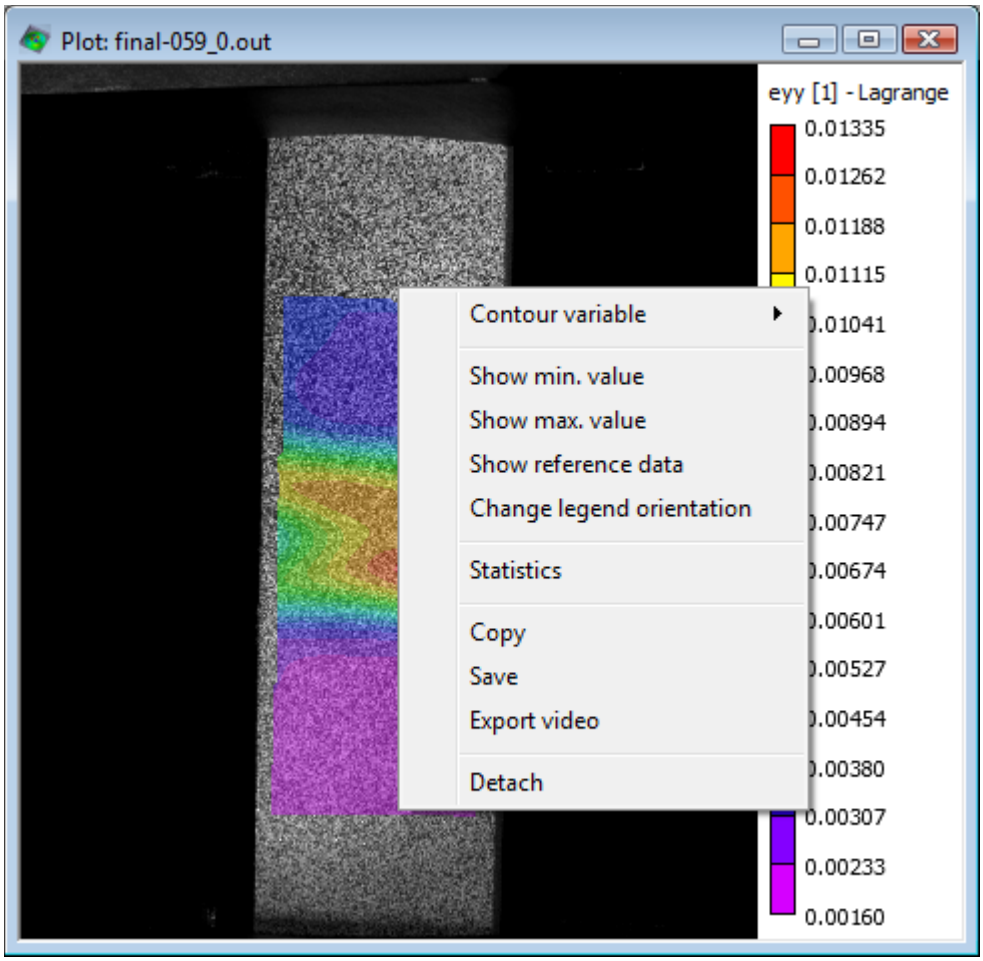
A plot of the data can be displayed by double-clicking on a data file in the list view to the left of the workspace.

A plot will be displayed in the workspace as shown below.



Plot Options

Plot options can be accessed by right-clicking in the plot window.



The *Contour variable* submenu can be used to select the variable to display.

Click *Show min. value* or *Show max. value* to flag the location of the minimum or maximum value for the currently selected variable.

Click *Show reference data* to view the data overlaid on the reference image rather than the deformed.

Click *Change legend orientation* to toggle between vertical and horizontal legend format.

Click *Statistics* to view a summary of data for the current image, for the currently selected contour variable.

Click *Change legend orientation* to toggle between a horizontal and vertical legend.

Copy copies the current plot to the clipboard; *Save* allows saving the plot as an image file.

Select *Export video* to save an animated video.

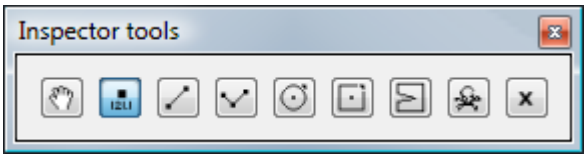
Click *Detach* to keep this plot static instead of updating it each time a new data file is clicked in the Data tab.

Editing Plot Parameters

To edit other plot parameters, use the plot toolbar.

Inspector Tools

Tools for probing and extracting data are located in the Inspector Toolbar, and can also be selected by clicking *Plot... Inspector* in the main menu bar.



From left to right, the tools are:

- Pan/Select: Pans around the contour image, when zoomed in; selects existing extract points. To select an item, click on the small square handle.
- Inspect point: select this tool and click to probe at a single point. The value for the currently selected contour variable, at the chosen point, will be displayed.
- Inspect line: select this tool and click once to start a line; click again to finish. The value will be displayed at each node.
- Inspect polyline: select this tool and click to create line nodes; double-click to finish. The value will be displayed at each node.
- Inspect circle: select this tool and click to define a center; click again to define a disc. The value at the center will be displayed.
- Inspect rectangle: select this tool and click to define a center; click again to define a rectangle. The value at the center will be displayed.
- COD (Crack Opening Displacement) tool: use this tool to calculate crack opening parameters.
- Delete: choose this tool and click on an existing point/line/area to remove it.
- Extract: click to open the Extract Sequence Data or Line Plot dialogs. For the line tool, data will be extracted alone the line for the current image. For the other tools, data will be extracted at the selected point or area, for each image, as a time sequence.

Animating Plots

To animate contour plots, bring up the plot display and then use the controls on the Animation Toolbar to animate the sequence.

Saving the Plot

The displayed plot can be saved as a BMP, PNG, or JPG image file by selecting *Save* from the context menu. To copy the plot to the clipboard, select *Copy*.

Output Variables

Introduction

During correlation and optional post-processing, Vic-3D presents a wide range of output data available for 3D and contour plotting, extraction, and export.

Output Variables

Always Present

- x / y [pixel] - point location in the reference speckle image
- u / v [pixel] - pixel displacements
- sigma [pixel] - this is the confidence interval for the match at this point, in pixels.
- x / y / u / v [mm] - these are metric coordinates and displacements, when a calibration is present

Generated in Postprocessing

Strain Variables

- exx [1] - strain in the X-direction. Positive numbers indicate tension; negative numbers indicate compression.
- eyy [1] - strain in the Y-direction.
- exy [1] - shear strain.
- e1 [1] - the major principal strain.
- e2 [1] - the minor principal strain.
- gamma [1] - the principal strain angle in radians, measure counterclockwise from the positive X-axis.

Velocity Variables

- dU/dt [mm/s] - the rate of change of the U-displacement; that is, the velocity of a given point in the X direction.
- dV/dt [mm/s] - velocity in the Y direction.
- dExx/dt [1/s] - the rate of change of strain in X, or strain rate in X.
- dEyy/dt [1/s] - the strain rate in Y.
- dExy/dt [1/s] - the shear strain rate.

Rotation Variables

- phi [1] - the in-plane rotation, in radians.

Key Terms

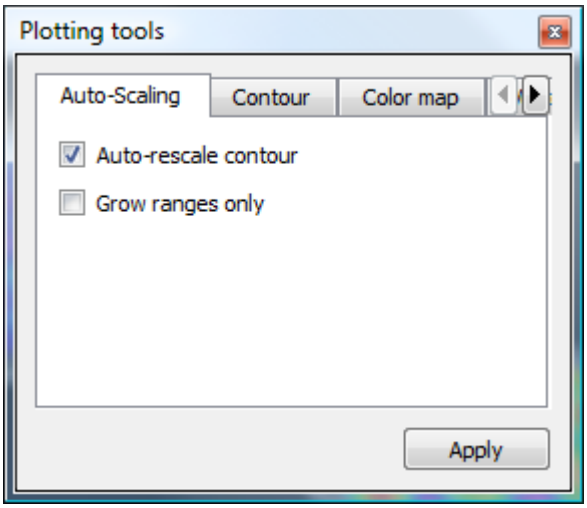
Strain: the change in length, divided by initial length, for a solid material. For example, a strain of +10% indicates that the material has expanded by 10%; a strain of -10% indicates that the material has contracted by 10%. Positive strains are referred to as tensile, while negative strains are compressive. Note: this is a finite strain tensor and contains a quadratic term; for significant strains, this may result in a strain measure which is larger than the small strain indicated by a strain gauge or extensometer.

Principal strain: the strain for a reference frame that is rotated such that shear becomes zero, leaving only two strain components at 90ï¿½ angles. The larger strain becomes the major principal strain, and the smaller becomes the minor principal strain.

The Plot Toolbar

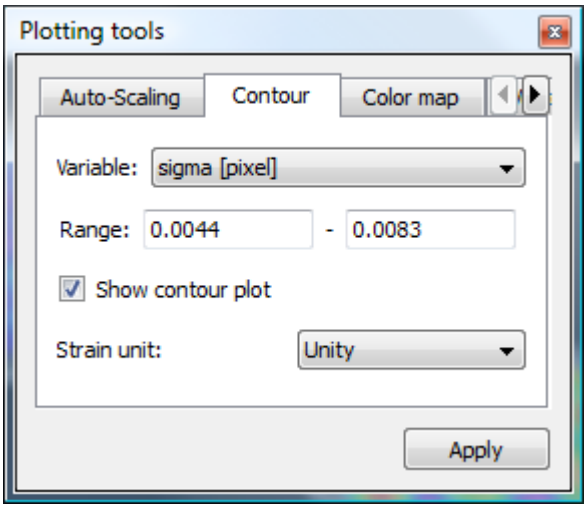
The plot toolbar is displayed at the top left edge of the work area by default. It contains options and controls for both the 2D and 3D plots.

Auto-Scaling



This tab controls auto-scaling. Check or clear the boxes to enable auto-rescaling of either coordinate axes limits, or contour overlay limits. Check *Grow ranges only* to allow ranges to get larger but not smaller. With this box checked, you can animate through all images to set the limits to the minimum and maximum over all data files. This is useful for producing consistent animations and videos.

Contour

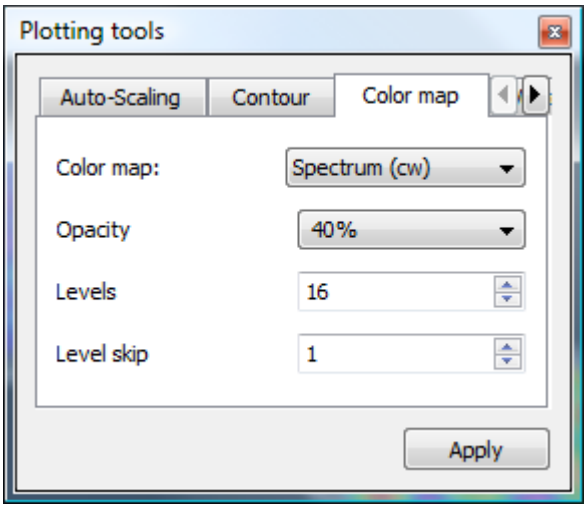


This tab allows control of the contour overlay of 2D or 3D plots. To automatically scale these values to fit the data, check the *Auto-rescale contour* box. To manually set the limits, clear this box and enter the desired values.

To enable or disable the contour overlay in 3D mode, select *Show contour plot.*

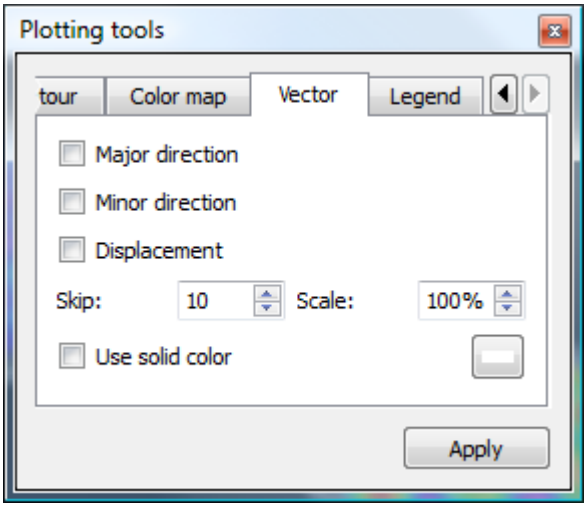
Use the *strain unit* control to determine how strain values are displayed; the default is unity, i.e., mm/mm.

Color map



Use this tab to control the display of contour overlays. The *Color map* box chooses the overall color set for the plot. The *Opacity* box sets the opacity of the overlay. The *Levels* box sets the n box sets the number of discrete contour levels. The *Level labels* box controls the number of numeric level indicators.

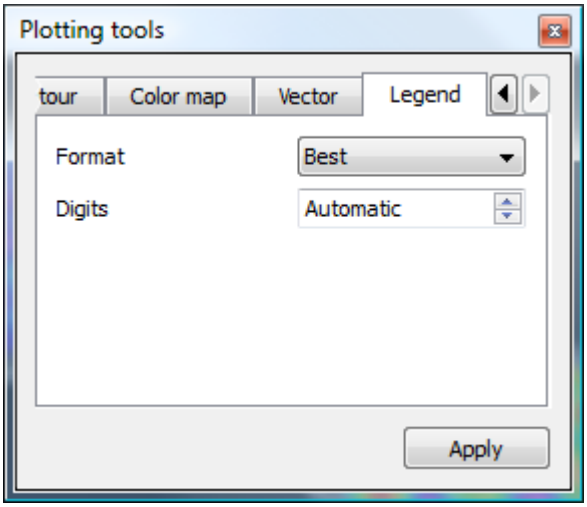
Vector



This tab controls display of strain and displacement vectors.

Major and minor strain direction vectors are displayed when strain data is available *Skip* and *scale* control the size and density of the vectors. The *use solid color* checkbox causes the vectors to be displayed in a single color rather than the underlying plot color; the color selector button can be used to choose this color.

Legend

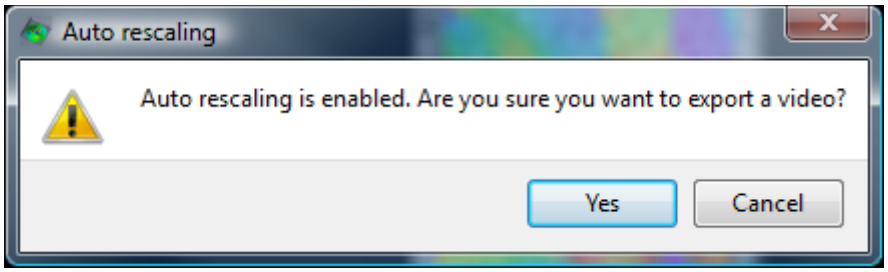


These controls affect the format of the contour legend. Select a *Format* from Number, Scientific (exponential notation), or Best (most concise method). Select a number of *Digits*, or Automatic to use as much precision as necessary.

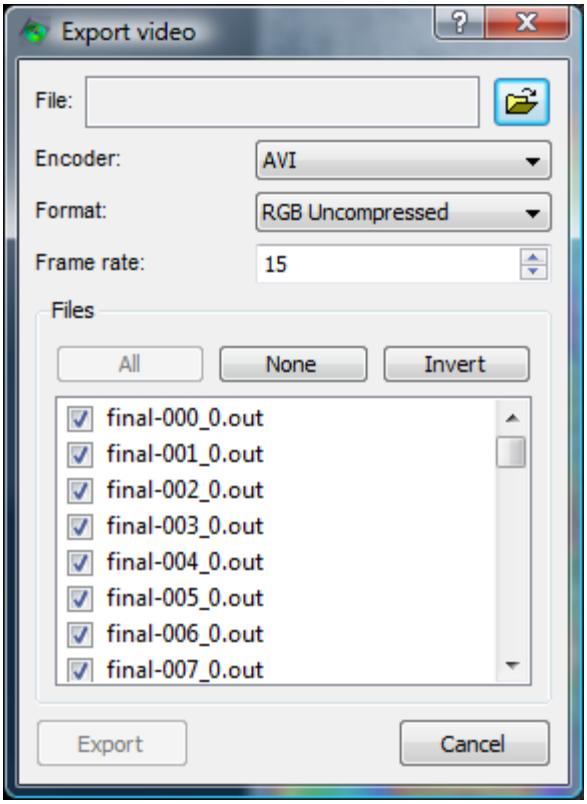
Exporting Videos

To export an animation from a plot, right-click in the plot and select *Export Video*.

If the auto-rescaling feature is enabled for contours, you will see a warning:



When rescaling is on, the animation may not appear as expected because each frame will be scaled differently. Click *Yes* to continue or *Cancel* to correct the condition. When complete, the following dialog appears:



File

Click the icon to select a filename for saving.

Encoder

To export a video file, select *AVI* from the Encoder drop-down; to export individual frames as separate, numbered files, select *Image Sequence*.

Format

Select from available compression formats; options will vary based on system configuration and installed codecs. Indeo(R) Video 5.11 works well for most Windows XP systems. RGB Uncompressed videos will be high quality but very large.

Frame rate

Select a frame rate in frames per second for the video.

Data File Selection

The available data files are displayed in the list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files; the *Invert* button inverts the selection.

To begin, click *Export*; a progress bar will indicate completion.

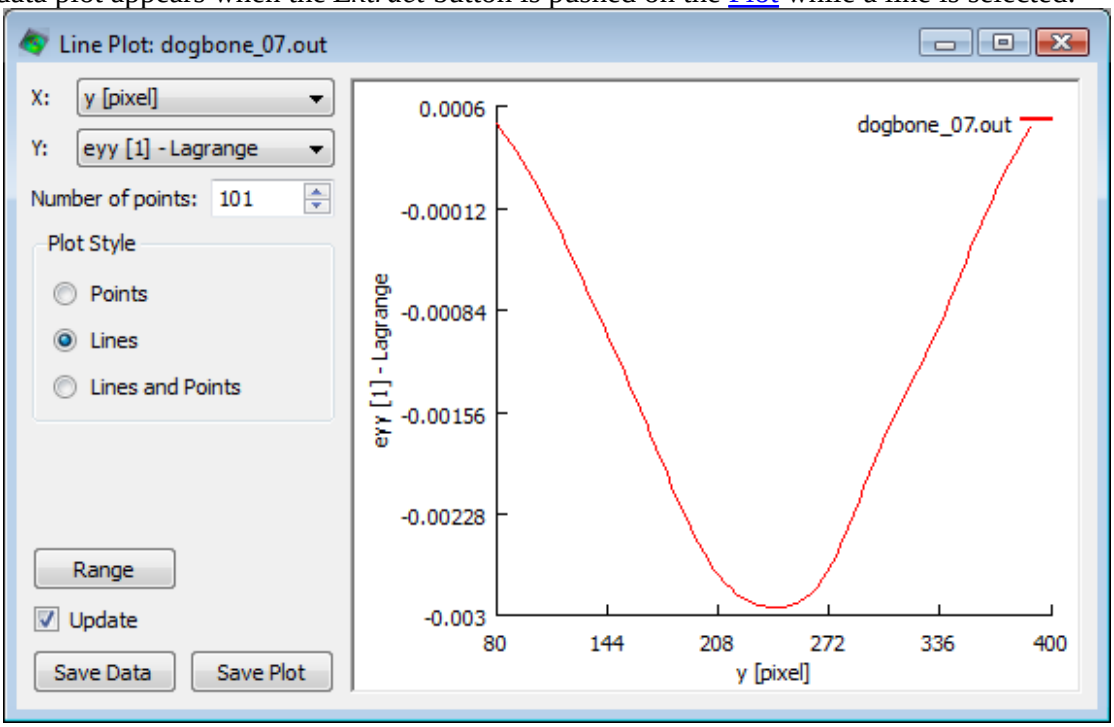
Line Plots

Line plots can be generated by using the Inspector Tools in a plot. There are two types of line plots currently available:

- Data extracted along a line
- Data extracted from a sequence of data files

Line Data Extraction and Plotting

The line data plot appears when the *Extract* button is pushed on the Plot while a line is selected:



Adjusting the Number of Data Points

The number of data points that are extracted from the data file along the line can be adjusted using the *Number of Points* control on the window.

Range

Click *Range* to select the x/y axis limits. To compute limits automatically (the default), click *Range* and select the *Auto-scale* checkbox.

Update

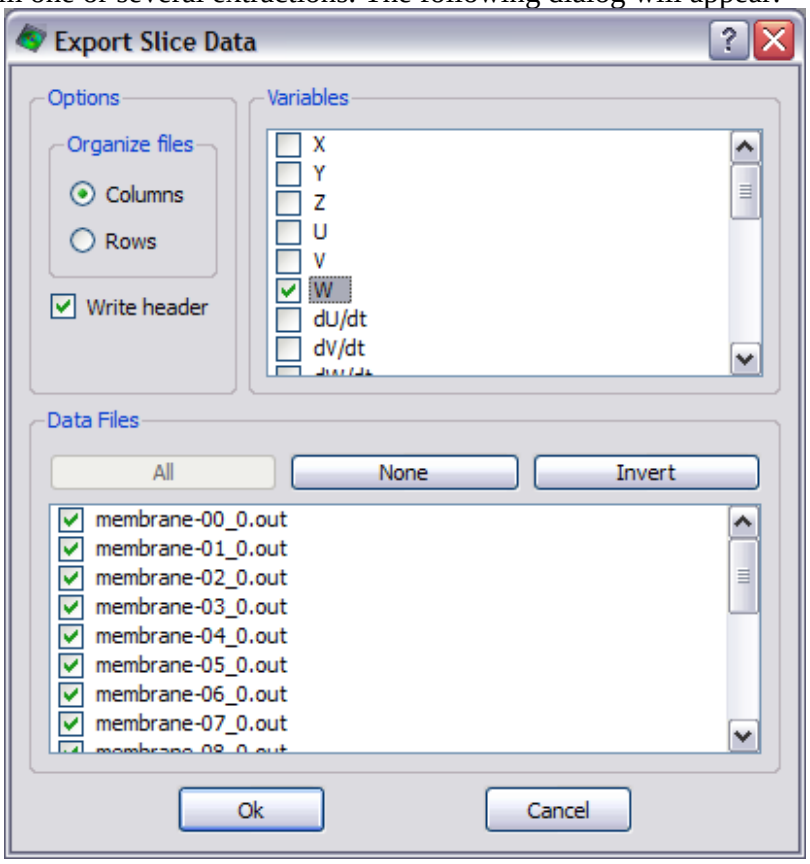
When the *Update* box is checked, the plot will update when a new file is selected in the Data tab..

Plot Style

The plot style can be selected to either show data points, lines or data points and lines.

Save Data

Click to save data from one or several extractions. The following dialog will appear:



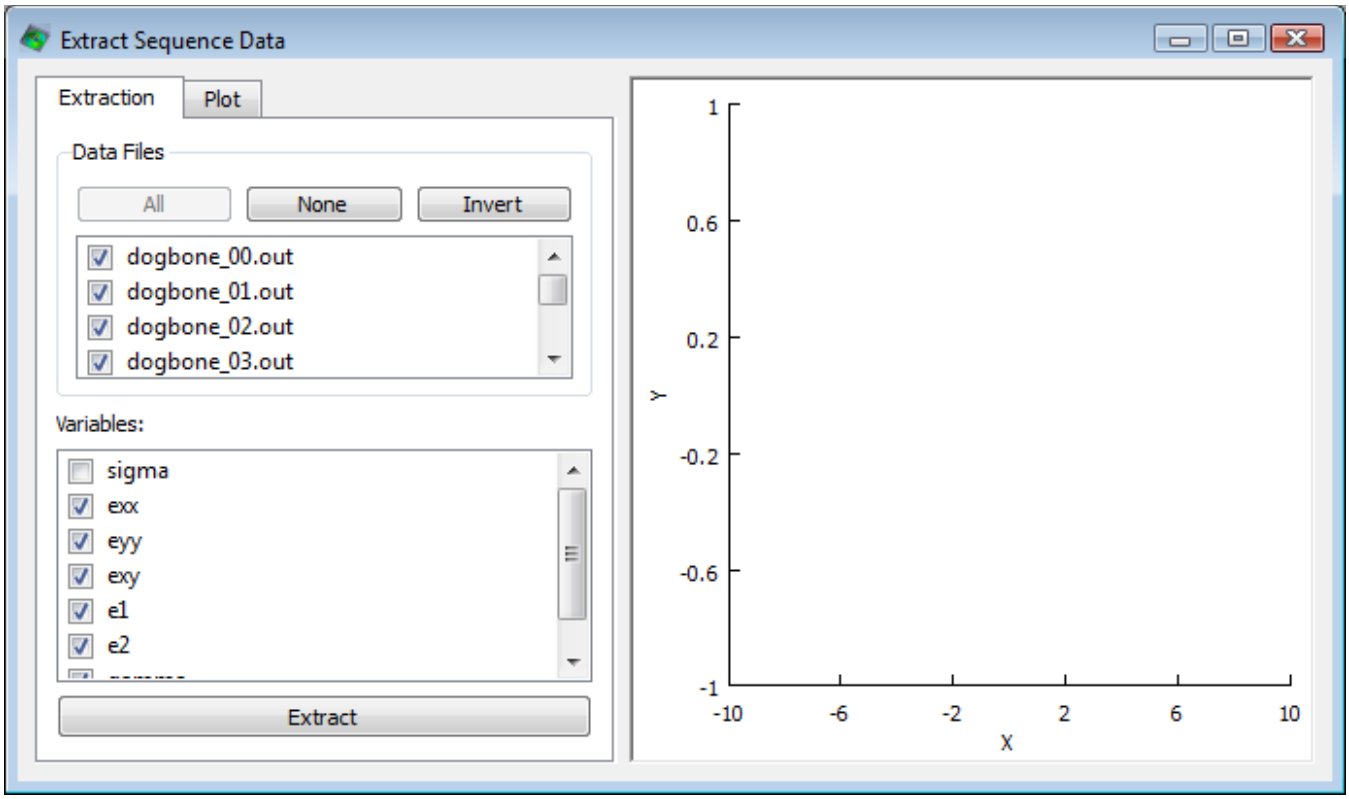
Select the variables to extract and the files to include in the extraction. The data may be organized by columns or rows; to include a row/column header which contains the name of the relevant data file, select *Write header*.

Saving Plots

The plot can be saved as a BMP, PNG, or JPG image file by pressing *Save Plot* in the bottom left of the plot window. You may also copy the plot to the clipboard by right-clicking on the plot area and selecting *Copy*.

Sequence Data Extraction and Plotting

The sequence data extraction window appears when the *Extract* button is pushed on the 2D Plot while a point, circle, or rectangle is selected:



Selecting Data Files

The data files used for extraction can be selected in the listbox in the top left of the window on the *Extract* tab.

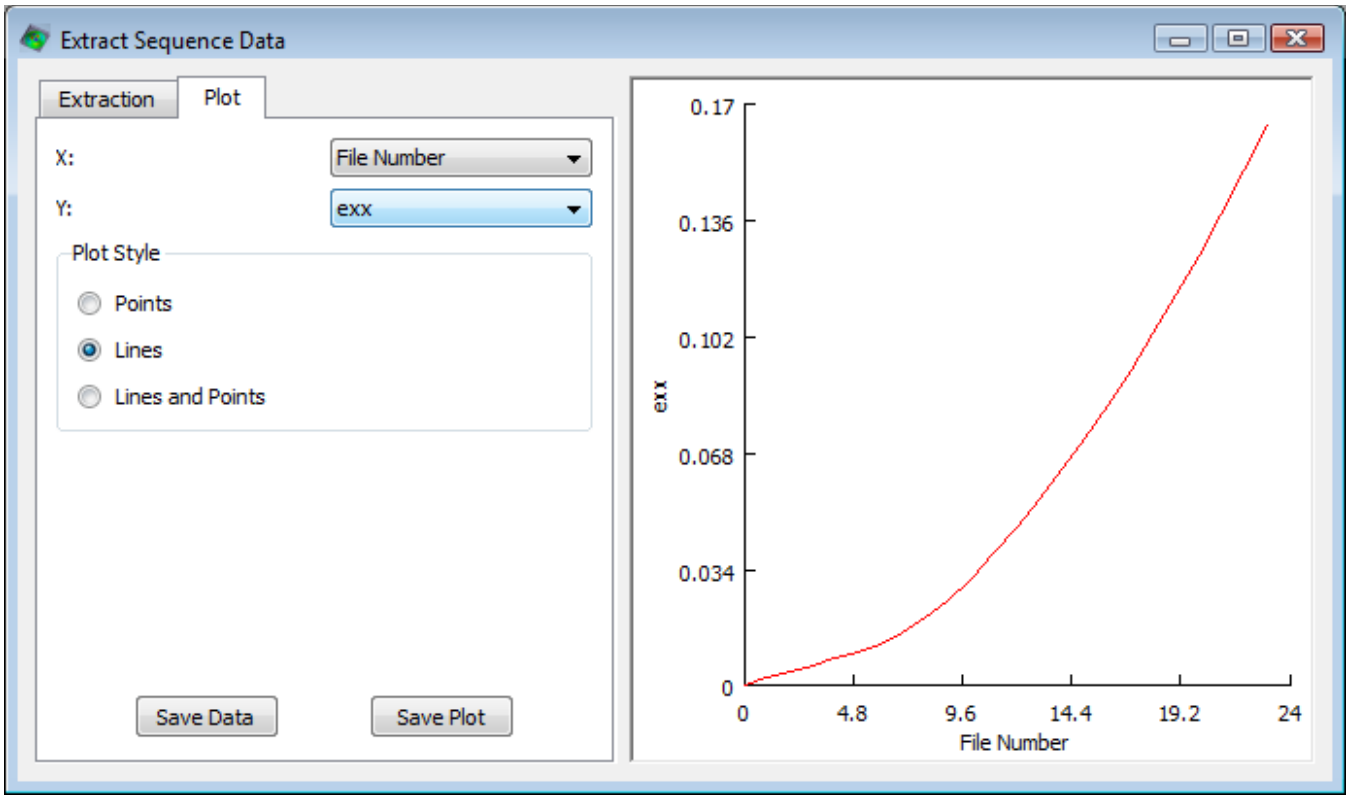
Selecting Variables

The variables to extract from the files can be selected in the listbox in the bottom left of the window on the *Extract* tab.

If an analog data file is present, time and analog data values may be selected for either axis.

Extracting the Data

After selecting the data files and variables to extract, push the *Extract* button to extract the data. Depending on the size and number of data files, this might take some time and a progress indicator will be shown to indicate the extraction progress. After data extraction, the *Plot* tab will become active and the window will appear as follows:



You can select from available variables for both X and Y axes. For an extensometer extraction, the available values will be D0 (initial distance), D1 (deformed distance), and E (strain). This is not a Lagrangian strain but only the first order change in length divided by initial length term.

Plot Style

The plot style can be selected to either show data points, lines or data points and lines.

Saving Data

The extracted data can be saved as a comma-separated variable file by pressing the *Save Data* in the bottom left of the plot window.

Saving Plots

The plot can be saved as a BMP, PNG, or JPG image file by pressing *Save Plot* in the bottom left of the plot window. You may also copy the plot to the clipboard by right-clicking on the plot area and selecting *Copy*.

Quick Start

There are only a few steps involved in obtaining deformation measurements from your images. If you are using Vic-2D for the first time, take a look at the example provided with the program. Then, try to go through the following steps yourself to quickly familiarize yourself with the program usage:

1. Add a reference image and select your area of interest.
2. Add more speckle images.
3. Run the correlation analysis.
4. Plot the results

If you encounter any difficulties, please do not hesitate to contact our technical support department .

What's New in Vic-2D 2009

- New matching algorithm for improved accuracy.
- Multi-core parallel processing for major speed increase on modern PC's.
- Confidence interval reporting on displacement data.
- More flexible AOI selection.
- Improved plotting and extraction tools.
- New thresholding options for accurate rejection of incorrect data with minimal loss.
- Arbitrary math functions can be created, saved, and applied to data; compute resultants, custom strain tensor values, and more.
- Improvements in data export including new Matlab format.
- Improved strain calculation accuracy and more flexible options.
- Incremental correlation option tracks strains to 1,000% and above.

Technical Support

If you cannot find an answer to your question in this manual, please do not hesitate to contact our technical support at support@correlatedsolutions.com. You can also find contact information at our web site at www.correlatedsolutions.com.

We will be happy to assist with topics such as:

- Designing digital image correlation experiments
- Troubleshooting errors
- Interpreting test data
- Achieving optimal results

Bug Reports and Feature Requests

If you encounter a bug in Vic-2D, please let us know about it. Send a short description of the problem to support@correlatedsolutions.com, along with any project or image files you think may help us reproduce the bug.

Also, if you think Vic-3D can be improved by adding a particular feature you would find helpful, let us know about it. We will try to incorporate your requests in our future updates of the software.